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PROCEEDINGS OF CONFERENCE
OF MEN ENGAGED

IN

GRAIN DUST EXPLOSION
AND FIRE PREVENTION
CAMPAIGN

CONDUCTED BY

United States Grain Corporation

IN COOPERATION WITH

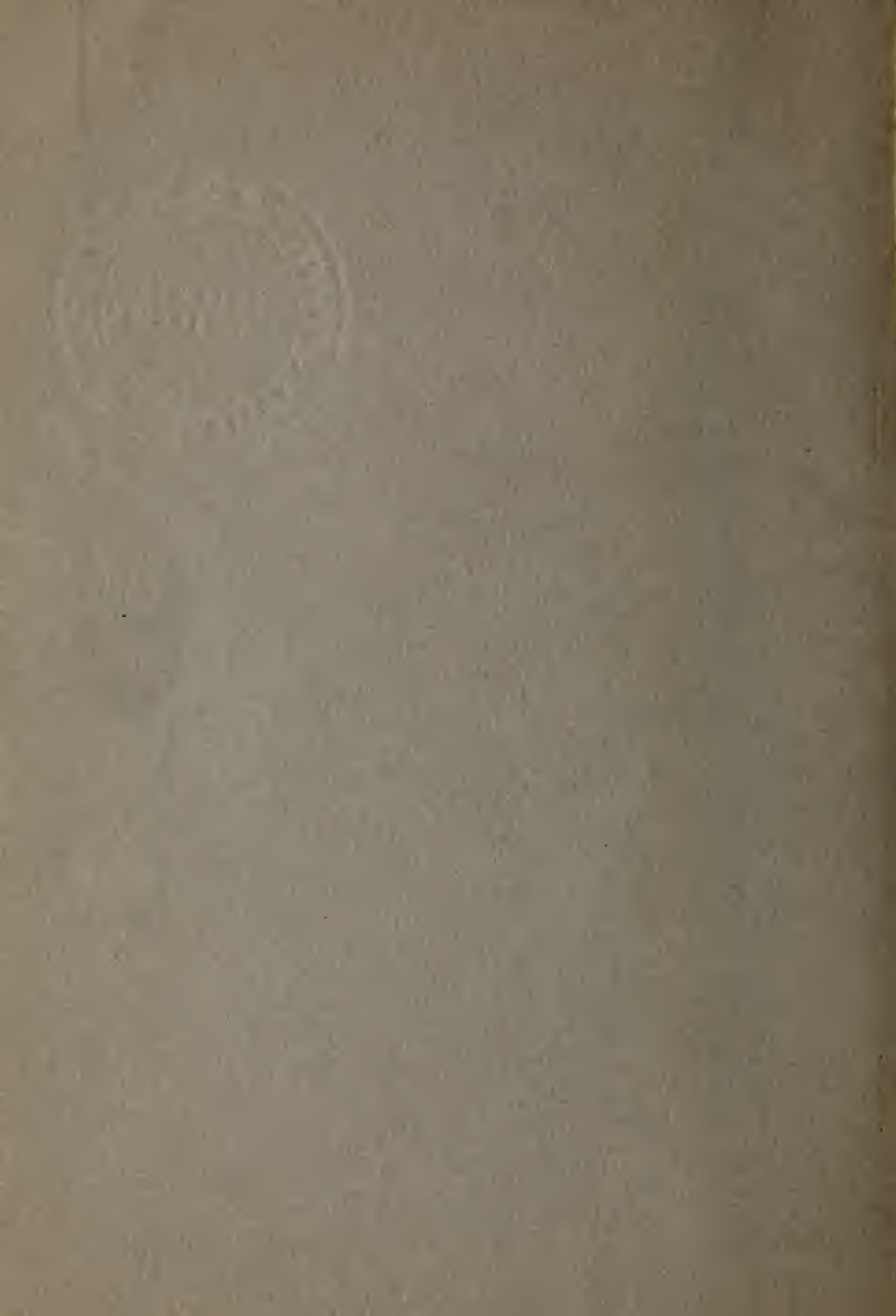
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PROCEEDINGS OF CONFERENCE OF MEN ENGAGED IN GRAIN DUST EXPLOSION AND FIRE PREVENTION CAMPAIGN

Conducted by

UNITED STATES GRAIN CORPORATION

In Cooperation with

Bureau of Chemistry, U. S. Department of Agriculture
42 Broadway, New York, N. Y.

April 22-24, 1920

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OPENING SESSION, THURSDAY AFTERNOON

April 22, 1920

D. J. PRICE, PRESIDING

Mr. PRICE—The dust explosion prevention campaign initiated by the U. S. Department of Agriculture in October, 1917, has been continued by the U. S. Grain Corporation since July 1, 1919. This conference of field men engaged in this work has been called to consider and discuss certain important phases of dust explosion and fire prevention work that have developed during the progress of the campaign. In addition to the men who are actually engaged in this work, we have in attendance others who have been interested in its conduct. We are glad to welcome them and invite them to assist in the consideration of the various subjects.

The conference will be somewhat similar to the one held a year ago in Chicago in connection with the war emergency campaign. The program as outlined will include the more important developments pertaining to this work.

In addition to the subjects listed in our program, we are to have the honor of having Mr. Barnes, President of the U. S. Grain Corporation, and Dr. Alsberg, Chief of the Bureau of Chemistry, address us sometime during the afternoon session on Friday. Mr. Moore, Vice-President of the U. S. Grain Corporation, has also very kindly consented to address us on Saturday morning.

The first subject presented will be "Possible Lines of Extension of Dust Explosion Work in Commercial Fields," by H. R. Brown, in charge of the work in the Eastern District.

"POSSIBLE LINES OF EXTENSION OF DUST EXPLOSION WORK IN COMMERCIAL FIELDS."

By HYLTON R. BROWN

This is certainly a broad subject but I believe it covers the keynote of the entire conference, that is: "How can the dust explosion work be continued?" or rather, "How can the results of our investigations be put on a practical working basis?"

Now we must admit that at present there are no funds available to continue the work in its present form after July 1. That does not mean that the work is finished but rather that it has been divided into a number of smaller working units. As we go out into other fields we are going to carry the dust explosion work with us. Some of us will go with milling or grain companies, others with insurance companies or various kinds of manufacturing concerns. Wherever we go we can carry the story of dust explosion prevention and do our bit to keep the good work moving.



Dust Explosion Demonstration—produced by blowing dust into an open flame in a miniature elevator.

I would like to suggest a few methods which might be followed to accomplish this. If we cannot do the work ourselves we must ask other organizations to take it up. For our general inspection work in its present form the best results can probably be obtained through three organizations, namely, fire departments, insurance companies and industrial commissions. These organizations can insist on the plants in their districts being clean. You remember our motto: "*Dust free mills and elevators*"

are explosion proof." Can we not impress this on these organizations in such a manner that they will take up this phase of the work and see that the plants in their districts are properly protected? Whenever you have an opportunity to present our work before any of these organizations do so. The cheese-cloth method of demonstrating is very effective and easy to give. When an actual explosion is desired a packing case or heavy cardboard carton can be used in place of the miniature elevator.

At one place in the eastern district an explosion demonstration was desired and we did not have the miniature elevator with us. A cardboard carton was obtained, an 8-inch piece of pipe partially filled with starch inserted through a hole in one end, a flame placed within the box and the cover closed. The dust was blown into the box from the pipe and the explosion which followed was all that could be desired. By giving demonstrations of this kind to interested organizations and urging them to do all in their power to protect the property in which they are interested the good work can be continued. All this can be done without interfering with your other work and I know everyone will be willing to take a few minutes of their spare time to keep the dust explosion prevention work alive.

During our conference a number of suggestions will be made regarding changes in elevator construction, changes in equipment, and methods of eliminating dangerous conditions. These suggestions should be given to the mill and elevator construction companies so that they can make further tests and determine the most satisfactory method to adopt. The effectiveness of the revolving damper, vent pipe, and choke conveyor underneath attrition mills, should be brought to the attention of machinery manufacturers with the purpose of having them standardize this equipment and supply it with their mills. Can we not impress this matter on the manufacturers so that new installations will be arranged to reduce the dust explosion hazard in this equipment to the minimum?

The electrical companies have been doing some excellent work along the line of dust explosion prevention. When explosions due to electrical equipment were reported they immediately started tests to determine to what extent such equipment might be responsible for the starting of an explosion. Their investigations have shown beyond a doubt that an explosion can be started by the breaking of an electric lamp in a dusty atmosphere. Further tests are being made by these companies to determine the best method of protecting these lamps from break-

age. In fact, a complete study is being made of the lighting system used in mills and elevators. This is a form of co-operation which amounts to something. These companies are much better equipped than we are to carry on investigational work of this kind and their co-operation represents the first step in the extension of dust explosion work in commercial fields. The results of their investigations can be taken to the mills and elevators in the form of better and safer lighting equipment.

Can we not arrange other co-operative work with various commercial concerns? We have started the ball rolling. Why not have machinery companies, mill builders and dust collector manufacturers take up the work and complete the investigations which we have started?

The Public Health Service should also co-operate with us in eliminating the dust condition in mills and elevators. In a number of plants the dust is so thick that it menaces the health of the employees, yet the company is not allowed to install a dust-collecting system because it might cause a difference of a few pounds between the incoming and the outgoing weights of the grain handled. Cannot the Public Health Service insist that the health of the employee is worth more than the slight loss in the weight of grain, and see that dust-collecting systems are installed? They would be helping the employee, the company, and, indirectly, the dust explosion work, because dust-free mills and elevators are explosion proof. I would suggest that we arrange, if possible, to have this organization co-operate with us.

Another method of extending our work is by using moving pictures and magazine articles to bring the subject before the general public. I believe a very interesting moving picture could be prepared for public showing. Our present pictures are adapted more for use in lectures before technical societies.

If the magazines will publish an article occasionally on the subject of dust explosions, or we can have a live story written about the work for one of the popular magazines, the work will be kept before the public and their interest in the subject maintained until we are able to put the work on a sound foundation and resume our investigations.

I have endeavored to make a few suggestions for the extension of the dust explosion work. Perhaps you have other suggestions along this line. If you have, I would suggest that you give them at this time so that we can prepare a program of co-operation and arrange for the continuation of the work in which we have all become so interested.

Mr. PRICE—This subject was placed on the program first because it was thought that there have been so many commercial lines along which the work might be applied, that we could well spend a brief time in discussing some of these phases. You recall the Department of Agriculture discontinued to a large extent the research work relating to dust explosions and fires, at the beginning of the war emergency campaign. Milling companies and other industrial concerns in the meantime have taken up parts of the work of interest to us. We will now devote a brief time to discussion and I hope you will feel free to respond without any hesitation.

Dr. DUVEL—I am very much interested in the health question Mr. Brown referred to. I would like to know whether you have run across anything to indicate the effect of dust in mills and elevators on the health of employees. Is it probable that rye dust and barley dust would be more objectionable than dust from either wheat or corn?

Mr. BROWN—I have never run across anything definite along this line. Rye, barley or some form of oat dust would probably offer the greatest objection in the elevator line. I was referring more especially to the smut millers in flour mills. I know of two cases where men engaged in this work have had to give up the job. In another case the man seemed to enjoy very good health and put on weight. Two out of three of the men I knew did have trouble.

Dr. DUVEL—You find men complaining a great deal as to the bad effects of working in a dusty atmosphere, yet there are men who have been working under such conditions practically all their lives and still apparently enjoy good health.

Mr. BROWN—Some claim it doesn't bother them in the least, while in some cases new men go in there and are not able to stand it. I think this question came up a year ago at the Chicago meeting. The question was raised by Dr. Hulett of Princeton regarding the health of people in Pittsburgh. I recall it was shown at that time that the tuberculosis death rate in Pittsburgh was lower than in any other city. Whether smoke had anything to do with it or not I don't know.

Dr. BROWN—From that side of the question, a little article which came across Mr. Price's desk and mine yesterday regarding a survey which had been made of the industries at Niagara Falls, published in a recent issue of the St. Louis Medical Journal

might be of interest. It was found that workmen throughout various types of industrial plants there became diseased on account of the dust, even though apparently there was a very small amount, at least as we see it from the mill and elevator standpoint, in the atmosphere. When the dust was breathed into the lungs it was not given out, but retained in the lungs and eventually brought about congestion and disease. In thinking over that side of the question it seems possible that when grain dust is taken into the lungs the starchy matter may be dissolved, being soluble in water, and consequently would not have the same effect but we might have that effect when certain dusts are considered. Possibly it might be more true in the case of rice dust, where the hull contains a very high percentage of silicate which, of course, is not soluble.

Mr. McCOLLAM—It seems to me that most everybody on this inspection work should have something to relate about the health of the employees in the mills they have visited. I remember particularly two plants, a rice mill and a grain elevator. The head miller in the rice mill had a very bad case of asthma which he attributed to the dust he had been breathing all his life. The man in the grain elevator also had asthma which he attributed to the same cause.

Mr. PRICE—The Public Health Service has done quite a little work in some other dusty industries and we hope this matter may be brought to their attention in connection with our work in the near future. In addition to this phase that has been suggested, there may be some other lines that might be considered. We would be glad to have the same presented.

Mr. BATES—I should like to ask you if there is at this time any plan relative to getting out a publication regarding grain dust explosions in mills and elevators, summarizing and giving results of this work?

Mr. PRICE—The Grain Corporation is planning that sort of publication right now, containing sufficient information to be of some value to the industry, as more or less of a report of what the Grain Corporation has been doing in this campaign. In addition, a manuscript is in course of preparation, which is almost ready to go into publication channels, covering the work from its origin in the Bureau of Mines in 1913 up to the present time. This is a very complete treatise of the question as it relates not only to grain dust but to other inflammable dusts as well. Both publications should be available during the present year at

least. The Grain Corporation publication will undoubtedly be ready soon.

Dr. BROWN—It seems to me that there are some things that we ought to bring to the attention of the mill construction people. For instance, we had a paper at our conference last year on the question of prevention of chokes in elevator legs. We are expecting to have a further discussion of that question at this conference. We had a paper last year on aspirating systems. We are to have a further discussion of that this year. In these and in many other cases, H. R. Brown referred to one—the case of the revolving damper, the choke conveyor and the vent pipe being standardized by the mill people—it seems to me that these and other ideas which have been brought out in the development of the work should be brought to the attention of the mill construction people but not, of course, given to them as finished products. We are not able to do that today. I sometimes doubt whether we shall ever be able to do that unless we can get into a plant and develop these ideas on a commercial basis. These people are able to do that, just as the electric lamp people with whom we are co-operating are able to make direct tests and do practical work. It seems to me that these ideas which we have should be given to these companies. Many of us probably may go out into other lines of work but I don't think we will ever forget the associations we have had, the ideas that have come to us. New ideas probably will develop from time to time. We will go into other industries where we may find other information on dust collecting systems that we feel would be more efficient in a mill or elevator than any type we have seen there. It will be worth while to keep in mind that the Department and the trade is interested in this problem and we can send to the Department and through them to the trade and to the mill construction people, some of these ideas. For instance, I ran across, the other day, a type of what is termed a smoke precipitator. It seems to me that it is something which could be developed, along a different line possibly, but to be used as a small type of dust precipitator. The method of operation was by centrifuging, you might say, the smoke. The solid particles in suspension were thrown to the outside and came out as a thick liquid, while the air, freed from smoke, passed on out. It seems to me that this idea might be developed in some sort of way as a dust precipitator, especially where we have quantities of very fine dust in suspension which it doesn't seem possible to collect efficiently at the present time.

Mr. PRICE—One of the very gratifying things in this work is that we have been able in the campaign to associate ourselves with some of the most prominent milling and grain men in the country. We are glad to have some of those men with us today. Professor C. H. Bailey of the University of Minnesota, St. Paul, came East primarily for this conference, which indicates the extent of his interest. He was in charge of our work for the first year in the Northwestern territory. We would like to have him discuss this paper.

Dr. BAILEY—I don't know that I have anything to contribute just at this point. I came to this conference primarily to obtain rather than to give information. These men might, however, be interested in the particular cause of my attending this conference. We are contemplating erecting, this summer, at Minneapolis, an experimental flour mill to include a rather elaborate grain cleaning department. We want to incorporate in that plant, as far as our finances make possible, the latest and most useful of modern ideas with respect to dust-collecting. I have little doubt that our grain cleaning department will be one of the most valuable parts of this project. I will appreciate it if you men keep this matter in mind during the course of my stay with you, that you may give me results of your experience and observation that will be of use to me. The plant which we expect to erect will not be large, but we hope to make it thoroughly modern. The mill is not being erected by the University or Experiment Station, but by the State Railway and Warehouse Commission. Our relations with them are very close and we are co-operating with them.

Mr. PRICE—Professor Bailey wants to erect a dustless mill and a dustless elevator in Minneapolis. He will appreciate the ideas of you men. If there isn't anything further on this particular subject we will take up our next number on the program.

At the time of the explosion in Kansas City last September (when the grain trade was wondering why this explosion occurred and the circumstances surrounding its origin) many theories were advanced as to how the explosion might have been prevented, and numerous suggestions made as to how this plant might be rebuilt to prevent another explosion from occurring. We, of course, as you know, were very directly concerned in that explosion. We have been longing for a considerable time to see an actual explosion occur. In connection with our thresher work in the Northwest, although approximately 500 explosions oc-

curred in one season, yet to my knowledge no man engaged in the work has actually seen an explosion. Men have reached the scene soon after an explosion and have left shortly before an explosion occurred. We have also wished we might be fortunate enough to see a mill or elevator explosion without being near enough to be in actual danger. We almost had that experience last Fall.

The engineer who prepared the report of the investigation of the Kansas City explosion advanced a number of ideas relative to construction that at the time appeared to be, I feel free to say, somewhat radical. When the report was sent to the Federal Grain Company we immediately received a request asking permission of the Department to turn this report over to the Burlington Railroad Company, who were rebuilding the elevator. Some of the ideas submitted by this engineer were not incorporated in our report as we did not feel sufficiently sure of some of the proposed changes. We later learned, however, that in the rebuilding of the plant the construction engineers were carrying out some of the ideas that we delayed action on at Washington. At that time we told Mr. Reed, one of the investigators, that when we had a conference of this nature we would give him an opportunity to prepare and discuss ideas prepared by him or by other engineers through him, regarding changes in elevator construction suggested by recent explosions. Mr. Reed will now discuss this subject.

“CHANGES IN ELEVATOR CONSTRUCTION SUGGESTED BY RECENT EXPLOSIONS.”

By J. O. REED.

During the period from May 22 to September 13, 1919, four months, there were five disastrous dust explosions in modern and so-called fireproof plants. These explosions occurred in two feed grinding plants, two grain elevators and one starch factory. Seventy men were killed, 60 injured and the property loss was estimated at \$7,000,000. Due to the fact that such a large number of explosions occurred in such a short period of time in these plants of the most modern type of construction, it seems quite appropriate that the subject, “Changes in Elevator Construction Suggested by Recent Explosions,” be presented at this meeting.

As stated before, some of the plants in which these explosions occurred were constructed entirely of concrete and steel. Heavy

walls with very few windows were used in the building structure. In fact, the building construction of all these plants was of such a nature that excessive pressures were built up when the dust became ignited. Long dust collecting and conveying systems were used in some of these plants, a fact which tended to enable rapid flame propagation. Because of these frequent and recent disasters the opinion is beginning to prevail that a modern grain-handling plant, constructed of fire-resistive materials, if not properly maintained, is more dangerous from a dust explosion standpoint than the old wooden type of plant. In a wooden house an explosion occurs and blows out one side of the building. Fire



Extensive damage resulting from explosion of starch dust.

follows the explosion, but in a large number of instances the sprinkler system, if not damaged by the explosion, extinguishes the resulting fire. In a concrete house, however, the explosion is very violent because of the high pressures that are built up within the building, due to the solid walls. Concrete plants however, in my opinion, can be constructed in such a way as to reduce the explosion hazard. The necessity for some change of construction is all the more emphasized by the loss of life and the damage to property.

In the construction of a building to prevent disastrous dust

explosions, provision should be made to prevent high pressures from being built up within the plant because of heavy wall construction. For this reason the suggestion is offered that the plant be constructed of very thin walls, a fact which could be made possible by the use of some wire or sheet metal frame to which is attached a very thin coat of cement, or, in other words, stucco wall construction could be used. If an explosion should occur in a plant built with walls of this nature very little resistance would be offered to the increase of the volume of gases produced by the ignition of the dust. In a building designed in this manner all the working stresses of the building, loads, etc., would be placed upon the concrete columns and beams used in the building structure. No stresses or weights would be placed upon the walls. The walls would only serve as a filler between the beams and the concrete columns.

As an additional means of preventing high pressures from being formed within the plant it is also advised that large window areas be used in the construction of the plant, or, in other words, the daylight type of building construction be used. In fact, it is suggested that at least one-third of the entire wall area of the plant be covered with windows. These windows should be of the steel sash type, should be self-supporting, and should extend from the ceiling to the floor. Very small panes with the thinnest possible glass which would not break by vibration should also be used. Provision should be made for the ventilation of the plant by having butterfly windows swing open horizontally from the floor and from the ceiling. As an elevator is usually several hundred feet high, there is usually a strong wind prevailing at upper stories of the plant. With these windows open on a windy day, from the top and from the bottom, the best possible ventilation would be afforded to the interior of the plant, especially in the "texas" of the building. There is a strong possibility that the wind at times would be so strong that a large amount of the floating dust would be blown out of the elevator through these windows. In speaking to a man who had worked in a plant in which windows of somewhat this type were used, I was informed that on certain days, when there was a high gust of wind blowing, they almost cleaned out the "texas" simply by opening the windows.

In order to prevent the accumulation of dust in a plant in such a manner that a dust explosion could not become disastrous, and also for the purpose of making it easier to keep a plant clean, all ledges or surfaces in the plant where dust may ac-

cumulate should be placed at an angle greater than the angle of repose of dust. In a plant of this nature no dust accumulations can lodge overhead. All steel beams and girders should be covered with cement. As it has been proven that concrete is a good preservative of steel construction work, its use will serve as a means to prevent the rusting of the metal framework of the plant as well as to prevent the dust from accumulating overhead on the steel beams.

The bin floor of a grain elevator should be constructed flush with the top of the storage tanks for the purpose of eliminating the explosion hazard produced by dust accumulating between the top of the bins and the bin floor. Dust that accumulates in such a place becomes very old, dry and inflammable. When an explosion occurs in some other section of the plant this dust is thrown into suspension and acts as a feeder to the initial explosion. As the space is entirely open above all the bins an opportunity is given for the flame to propagate to all the bins and produce a very disastrous explosion. If, however, the bins are constructed flush with the bin floor, each bin is separate and an explosion in one bin is not very likely to propagate to many other bins.

The working floor should be very open with the entire weight of the building supported by heavy concrete and steel columns. Only a small percentage of the sides of the working floor should be covered with walls, and in place of these walls some type of rolling steel curtain doors should be used, which could be opened during the day to permit the greater part of the working floor to be open. Since there is no great amount of machinery on the working floor, and since there are only a few workmen outside of the unloaders in the working shed who ever remain on the working floor, there would be no objection to that portion of the plant remaining open. Large steel sash windows should be placed at intervals between the curtain doors to provide light when the curtain doors are closed.

The storage bins should be as small as is practical. As stated before, all bins should be covered and should have perfectly smooth sides to prevent dust from accumulating, a fact which was emphasized by the explosion in the plant at Port Colborne, Ontario.

The basement should be constructed only partially under the ground. If, for instance, an 8-foot basement is to be used, only 4 feet of the basement should be below the ground level. The 4 feet of the basement above the ground level should be

covered with very thin walls and a large window area. Provision should be made that these windows could be opened to provide ventilation and air to the basement. Then if an explosion were to result no great pressures and no rapid flame propagation would occur. By placing the basement only partially underground, the working floor of the plant would be a slight distance above the ground level, a fact which would require the cars that run under the working shed to be run up a slight incline plane to the working shed. This would have its distinct advantage, in some cases, for by the use of an incline plane to the plant the cars could be handled more readily due to the fact that the engine would push the cars up the plane to the working shed and the cars could then be easily handled by the workmen simply by permitting the cars to run by gravity to the unloading pits. If there are tunnels that run under the storage tanks, provision should be made that portions of the tunnel be open or confined only by means of very thin walls or windows. A vent at the end of a tunnel could even be suggested.

If by the action of the Boards of Trade and State Warehouse Commissions suction is not permitted to be used on elevator legs, it seems quite advisable that natural vents be placed on all elevator legs, bins, garnerers and scale hoppers in the plant. Scale hoppers and garnerers, especially should be vented to the outside for the reason that when grain is run into a scale hopper or garner the dust-laden air in the hopper and garner is forced out into the building. By the installation of a vent the dust-laden air, instead of being forced out into the building proper, will be discharged to the outside. If an explosion should occur in one of the places where there is a vent provided the vent would also serve to a considerable extent as a medium to relieve the pressure created within the place where the explosion occurs.

In the installation of a vent for elevator heads, it would seem advisable first of all to consider the construction of the elevator legs. In most of the elevators today the trunking of the elevator legs does not run direct from the boot to the head, but instead, in that portion of the plant where the storage section is placed, there is what is termed an "elevator well" through which the elevator belts run instead of in the elevator trunking. If the elevator building should at any time sag or vibrate there is no guarantee in an installation of this nature that the elevator head pulley shall remain in line with the pulley in the elevator boot. At the same time there is a great amount of dust that accumulates in this "elevator well" which is very difficult to

clean out. With some source of ignition, as for instance a spark from a bucket or from friction due to an elevator choke or legs becoming out of alignment, usually there is so much dust that a disastrous explosion results. As a means of preventing the possibility of the elevator head pulley becoming out of line with the elevator boot pulley due to the installation as just described, it seems quite advisable that the entire elevator leg or trunking be built solid and in one piece from the boot up to the elevator head. The elevator would then be self-supporting, would rest upon the floor in the basement, and would not be put out of alignment by the sag of the building. Heavy steel plate construction would be used for the elevator trunking so that if an explosion were to occur it would be confined until it reached the vent at the head. It seems quite natural that the elevator heads, due to the fact that they are so close to the roof of the building, should run out through the roof and there be capped by means of a ventilator of a special design which would serve to ventilate the lofters and provide an escape for the gas in the event of an ignition of dust. Natural vents on bins serve several purposes. They remove one of the greatest objections to the use of the closed bin, for the reason that they provide ventilation to the grain contained in the bin while at the same time they provide a relief for the air pressure developed as the grain is being run either into or out of the bin. Ventilators of some special type should be placed over these vents and should be so designed that sparks from locomotives would be unable to get in. Vents would probably be of some use in the tunnels underneath the storage bins where there is always poor ventilation and heavy dust clouds.

It seems to be the tendency in modern elevator construction to install extensive dust collecting systems which extend to all sections of the plant. During a very recent explosion the fact was brought out very conclusively that dust-collecting systems of an extensive character are very dangerous to have in a plant because by a lengthy installation an excellent chance is afforded for the flame to propagate through the trunking of the dust-collecting system to all sections of the plant. It seems quite advisable, due to this fact, that instead of one large system being used for the collection of all the dust in the plant, a series of small systems should be used. For instance, a separate system should be installed for the suction floor sweep in the "texas" and a separate system for the working floor and basement. It also seems advisable that the fans on all cleaning machines should exhaust directly into a cyclone dust collector installed outside

of the plant instead of into a main trunking which leads to a system of dust collectors. If suction is permitted to be used it seems quite advisable that a separate system be installed for the aspiration of the garners, a separate system for the scale hoppers, and a separate system for the elevator heads, etc. If it is necessary that a main suction trunk of any length be used it seems that instead of running this trunking through the center of the plant it should be run on the outside of the plant, for if then an explosion propagates through the dust collecting system it will be carried outside and probably do little damage. In this trunking outside of the plant some sort of a relief valve could be designed and installed which would relieve the pressure in the dust-collecting system and vent the explosion, thereby further reducing danger of damage.

All the trunking of the dust collecting system should be constructed in sections so that it is possible to take down the trunking and clean it out. This trunking should be of such a size that high air velocities shall prevail in the system for the reason that no dust is then able to fall to the bottom of the steel tube. All elbows of the trunking system should have a radius of at least twice the diameter of the pipe. All trunking should be properly grounded for static electricity.

Very recently there has been two explosions which originated in the suction fans used in connection with dust-collecting systems. This fact would seem to indicate that either the fans were not constructed properly to reduce to a minimum the possibility of the formation of sparks within the fan casing, or the fans were receiving poor care during their operation. To reduce to a minimum the possibility of the fan blades striking the sides of the outer sheet-iron fan casing, and to eliminate other fan troubles, the following recommendations and suggestions regarding the construction of fans are made for your consideration at this meeting:

1. The fan blades should be enclosed and fixed securely on the sides to a sheet-iron casing. The fan hub to which the blades are attached should extend about one-half inch beyond this fan blade casing. There should be a clearance of at least one and one-half inches between the fan blade casing and the outer fan casing. By an installation of this nature it seems quite impossible for a fan blade to become loose and strike the side of the fan casing and produce sparks.

2. The hub to which the fan blades are attached should be fixed to the revolving overhanging shaft by means of two tapered

keys, one key at each end of the hub, the angle between the keys to be 120 degrees. These keys should be held in place in the fan hub by means of set-screws which should be screwed into a small hole or seat in the key produced by the point of a drill bit after the key is driven into the hub.

3. In regard to the proper maintenance of the fan it appears quite essential that frequent inspections should be made of the fan to determine the clearance between the fan blades and the outer fan casing. For this purpose a door or some other opening should be provided in the side of the outer fan casing to facilitate inspection.

4. It seems quite necessary that some provision be made in the construction of the fan to provide for the end thrust of the fan and for the adjustment or clearance between the fan blades and the casing by means of collars being placed on the fan shaft next to the journals.

In making these suggestions regarding the construction of grain elevators it will be noted I have considered only elevators constructed entirely of fire-resistive materials, such as concrete, tile and steel. You gentlemen, due to the fact that recent explosions have occurred only in plants constructed of fire-resistive materials, may put forth the argument that elevators should be constructed of wood, since explosions have not occurred of late in plants of this type of construction. The following reasons are given in advocating the construction of concrete elevators:

1. The depreciation on an elevator built entirely of concrete is small, while the 5 per cent. a year depreciation on wooden elevators is a conservative figure. The depreciation and upkeep of the machinery is much less in a concrete building, owing to the solidity of the structural supports and the absence of vibration.

2. The safety afforded the elevator owner is a matter which must be considered. The day is past when the elevator can be replaced within 60 days. It is exceptional at the present time to secure the delivery of lumber required for the wooden elevator construction within that time. In past years almost immediate shipments could be depended upon from the lumber mills of northern Minnesota and Wisconsin. Now 90 per cent. of the lumber must come from the Pacific Coast.

3. It has been proven that reinforced concrete is the most flexible of all material in the construction of grain elevators and

storage tanks. It is claimed that 99 per cent. of the larger grain elevators and storage houses at the terminals, and possibly 90 per cent. of all the fireproof country elevators are now being built of reinforced concrete. Where grain, earth and water pressures are to be resisted, reinforced concrete is the logical material.

4. In a recent fire in the concrete elevator of a cereal company at Minneapolis, the fire resisting qualities of concrete were demonstrated. On the first floor of this elevator there were several attrition mills with wooden feed legs, sacking spouts, reels and conveyors. The fire burned out this installation but the only damage done to the building structure was a slight crumbling of the concrete over an area of a few square feet and to a depth of less than one-half inch, resulting in no serious injury to the strength of the bin bottom. If, however, the bin bottom slab had been supported on exposed steel beams, which I have stated before in this paper should be covered with concrete for the purpose of preventing dust accumulations from forming, the heat developed would have been sufficient to cause the steel to sag and possibly collapse under the load.

In my effort to present the subject of "Changes in Elevator Construction Suggested by Recent Explosions," I have only considered some of the important changes which I thought necessary. I have only touched the subject in a general way and have by no means tried to draw up a code or a detailed plan on elevator building construction. I desire a full discussion on some of the suggestions which I have made and for this reason I wish to give you a summary of some of the changes I have advocated. As you have noted, I have recommended that grain elevators be constructed of fire-resistive materials with thin walls and large window areas providing good ventilation. Half-basements, or no basements at all; comparatively open working floors, and enclosed bins have been suggested. The question of vents on garners, weighing hoppers, bins, and elevator heads, together with a change in the installation of the elevator trunking has been considered. I have advised that the elevator heads be run out through the roof of the building and vented, and also have dwelled upon the subject of dust collecting systems only in a general way by recommending that shorter and separate systems be installed. I, however, have gone into detail on the proper construction and installation of exhaust fans. Lastly, I have endeavored to show you the economic necessity of reinforced concrete elevator construction. It is these subjects which I de-

sire that you discuss and which I think demand some consideration in the construction of grain elevators for the prevention of disastrous dust explosions.

Mr. PRICE—Mr. Reed has covered this matter very thoroughly. Do you concur in everything that has been said about changes in construction to prevent disastrous explosions from occurring?

Mr. BODNAR—In the Northwest I came across two concrete elevators, each with a capacity of about 90,000 bushels, that had a peculiar construction which might help prevent disastrous dust explosions. Each of the elevators had five or six bins, the tops of which were open to the open air around the entire upper periphery. The openings were anywhere from $1\frac{1}{2}$ to 2 feet high. When the elevator operates so that grain is falling into the bins the wind or any breeze will clear out and carry away most of the dust in the air. If there was an explosion on the main floor there would probably be enough relief of pressure through the opening above mentioned that no serious results would occur. One of these elevators is at Walla Walla, Wash., and the other somewhere in Idaho.

Dr. BROWN—Are the bins all connected?

Mr. BODNAR—Yes. There was no floor on top of the bins. All of the bins were open. The opening I mentioned might just as well have been a window area with all of the windows knocked out.

Mr. REED—In the elevator I have considered the windows can be closed when it rains.

Mr. BODNAR—The operators of these elevators say they were never bothered by weather conditions.

Dr. BROWN—Most of the wheat in the Northwest can stand a little extra moisture.

Mr. PRICE—They leave a foot and a half or two feet between top of bins and floors?

Mr. REED—I advised that each bin be enclosed. Now in an installation of that nature, as Mr. Bodnar states, there is no dust that can accumulate between the bins and the bin floor.

Mr. BODNAR—There is no bin floor in this case, that is, the bins are open entirely.

Mr. PRICE—There are a number of questions I would like to bring up. In regard to the matter of thin walls, about how thick, approximately, should these walls be?

Mr. REED—The walls at Kansas City on the working floor were about six inches thick. In the construction of the shops used in the army cantonments and the like, which were constructed of concrete, they just placed in between the steel or concrete columns that were used a wire screen or something of that nature upon which they squirted a spray of cement, I think not over one-half inch or an inch thick. When I speak of a thin wall I mean a wall not over 2 inches thick.

Mr. BRADY—Is there any objection to a brick wall?

Mr. REED—That would be a little too thick.

Mr. PRICE—In addition to this matter of construction, Mr. Reed also suggested that the working floor be almost entirely open, a very small percentage covered. His theory is to have the working floor entirely open with a small part of it covered, and instead of a basement have an inclined plane to handle the cars. I would like to present that matter for discussion.

Mr. BRADY—I think there ought to be some work done relative to fans in elevators. The explosion that recently took place at Manitowoc shows that a steel fan is something to be reckoned with in eliminating explosions. Here was a case where a wire got into a steel fan, made a spark and caused the explosion, a thing that is apt to occur in elevators or mills. Fans, it seems to me, could be encased in some way so that you would have a plate on the inside of those fans, and the blades made of something other than steel, maybe bronze, aluminum or something of the sort that wouldn't strike a spark when it would hit along the side of the fan casing. A while ago an explosion occurred in Denver, supposed to have been caused by the fan running loose and going up against the steel casing. It there made a spark which ignited the dust in the dust-collecting system. Now this question could be presented to some of the people that make fans and have them make such provision.

Mr. PRICE—At what points in the elevator would the fans be located?

Mr. REED—At any point where suction is applied and an aspirating system used there should be a fan.

Mr. PRICE—The objection has been raised that some State regulations prohibit suction of any kind between the receiving point and the weighing of the grain.

Mr. BRADY—You can use indirect suction on the buckets or elevator leg at any time.

Mr. PRICE—This is all beyond the weighing point, I take it.

Mr. BRADY—The point I want to raise is to change the construction of fans.

Mr. REED—Why not construct a fan that a piece of wire can't get into very easily; one that can't work to the side and produce a spark—one that will not permit the fan blades to work to the sides? Aluminum is said to deteriorate in air where there is a great quantity of air being handled. This fact almost justifies that it be not considered.

Mr. BRADY—Other metals could be used, probably.

Mr. REED—Bronze would cost too much.

Mr. PRICE—The Manitowoc explosion was in an aluminum manufacturing plant—an explosion of aluminum dust in which the investigators assigned the cause to a metallic spark caused by a wire getting into the fan. The cause of the Denver explosion is debatable. Late developments bring out more doubt as to whether the explosion was caused by the fan slipping to the side. It would seem just as probable that it may have started in the rolls by sparks from foreign materials.

Mr. BRADY—On the subject of the fan, I am not quite clear on the inner casing that is referred to.

Mr. REED—The fan hub is keyed to the overhanging shaft by two keys, one at each end of the hub, the angle between the keys to be 120 degrees. The fan blades are enclosed and are also placed at an angle, a fact which I think is good construction.

Mr. PRICE—What is the objection to it? Is it a good idea?

Mr. BROWN—I understand that the blades of the fan are enclosed by a plate at each side. How are you going to get the dust out of the fan after it goes in?

Mr. REED—It comes out at the end that is not enclosed. Fans are being constructed that way today.

Mr. BROWN—Where does the dust go in?

Mr. REED—Into the eye of the fan.

Dr. DUVEL—The ordinary fan has two bearings, doesn't it?

Mr. REED—Yes. They are at one side of the fan casing. I am not speaking about an extra large fan. Almost all small fans used today have the overhanging shaft and all the bearings on one side of the fan casing.

Mr. ROETHE—Is that a multi-vane fan?

Mr. REED—No.

Mr. PRICE—We, generally, agree with the idea Mr. Reed has brought out, if this fan is going to solve the trouble. We have gotten just a little away, however, from some other features relating directly to construction. Mr. Reed said that he knew of an elevator in Baltimore where some of the ideas suggested were being carried out. What elevator is this, Mr. Reed?

Mr. REED—The Mount Clare Elevator operated by the B. & O. Its capacity is about 500,000 bushels.

Dr. BROWN—I might state my views in connection with some of the points that have been brought out, although slightly divergent from the last two or three points of which Mr. Price has spoken. The one with the basement largely above ground-level appeals to me as something well worth while. The Port Colborne elevator—Government elevator at Port Colborne—was so constructed. In fact, there was only about two or three feet below the surface and about ten or twelve feet above the surface. There was a window surface of the wall of easily, I should say, two-thirds of the portion of the wall above ground, but the interesting fact, as I will try to bring out in the review of that explosion tomorrow, was that the windows were drawn in and not blown out. The explosion was not in the basement, but should it have been in the basement and propagated through the basement, there certainly was enough window space and weak construction to have vented it and the remaining portion of the construction was probably sufficiently strong to have held the pressure that might have been built up back of this so-called light construction. If we are going to advocate light construction for side walls our super-structure would have to be of very heavy structure to withstand the force. If we have a proper mixture of dust and air to give us the most inflammable dust and air mixture, the rate of propagation and the pressure developed in the explosion is going to be so instantaneous that we are going to get a sudden destruction of everything unless a very

large area of the structure will give way easily and the smaller portion will be of sufficient strength to withstand, for a short time at least, that excess pressure.

In regard to the open structure and especially in the "texas" that question was considered very seriously in connection with the Port Colborne disaster and was brought up at the hearing held in Port Colborne sometime after that. It seems to me, although we probably do get a certain amount of ventilation and a certain amount of the dust carried out, that if we have enough dust present in suspension in the elevator so that seemingly a large enough quantity must be carried out to reduce the hazard, we certainly are going to get a sufficient quantity accumulated to make a very dangerous condition. Unless the walls are light and largely open we are going to have enough pressure developed in case of an explosion to be very dangerous. In the elevator at Weehawken the walls were of very light construction, might say, above the bin floor. To the roof of the bin floor the walls were of brick and about 8 to 10 inches thick. The "texas" walls were of 4-inch hollow tile. The side walls of the bin floor withstood all pressure developed and were not pushed out to any extent, but the walls of the "texas" were largely blown down. I was in that elevator only a short time after the explosion happened. They had not cleaned up at all and there was only a very small quantity of dust accumulated anywhere. It was interesting to note the path of the explosion through the "texas." On some of the girders the dust on three sides had been charred while the dust on the other side was not charred. There was some dust on this side but not much. There was a normal quantity of dust on the sides of the elevator and the floors were quite clean. This illustrated to me the ease with which an explosion will propagate through a comparatively small quantity of dust, seemingly, which may have accumulated on the side walls or on the beams, etc. There was no evidence of dust on the beams in this Weehawken elevator and the side walls were very clean. I have never been in but one elevator which was cleaner.

Mr. BODNAR—In two elevators of about the type I have referred to, I have found Mr. Reed's idea carried out in so far as the well or manlift shaft of the elevator is concerned. This well was constructed of wire netting covered by concrete not over one-half inch thick. These two elevators are in Idaho.

Mr. McCOLLAM—In regard to Mr. Reed's point about eliminating elaborate dust-collecting systems, in an Ogden ele-

vator of one-half million bushels capacity, the only dust-collecting system is their battery of cyclone dust-collectors on the cleaning machinery. This is located on the outside of the elevator. No suction is applied anywhere in the elevator. They have a very tight job of millwrighting throughout the elevator. Every joint in the steel elevator legs is packed very tightly with felt, and all other joints in the scale hoppers and garners are likewise packed very tightly.

Mr. BATES—I would like to ask if this thin wall suggested of stucco on metal lathing isn't supported between the spans as is ordinary siding?

Mr. REED—If I remember correctly they put this wire up with very little support at all. Immediately back of the wire they put up heavy boarding and shot the concrete right up against it with a cement gun.

Mr. BATES—Unless these spans are short, such a wall would not sustain a very great pressure from the outside, as in the case of a high wind, and in that kind of construction at any place where there was weight or constantly changing pressure you would expect it to crack and give trouble.

Mr. REED—I think there was some siding.

Mr. BATES—Would it not be well to recommend light construction between the framework of the supports, not attempting to say what that light construction should be, in preference to giving our ideas in regard to any particular structural design? If we attempt to specify definitely shapes and thickness we are bound to get into trouble.

In Mr. Reed's suggestions he brought out some very interesting points in fan design. I believe whatever is given to the industries in the way of specifications should be very general. In fact, in that kind of fan there is no way you can hold the propellers from slipping to the outside, because if the fan becomes loose on the shaft the shaft does not go through the fan hub. The idea of making the blades narrow at the tip is to keep the velocity of the air the same at all points, which is desirable, especially in high-speed fans.

Mr. WATERS—In regard to the stucco construction Mr. Reed spoke about, it may be all right on upper stories, but in an elevator it is just as necessary to try to eliminate fire from the outside. If there is a fire nearby you wet down the elevator

to keep the fire from coming in contact with the elevator. In that case those stucco walls will under no condition stand any pressure of water. They would therefore not be very appropriate on the first floor.

Mr. REED—You are talking about fireproof construction. What we are considering is explosion proof, not fireproof construction.

Mr. WATERS—Stucco of that sort would not be fireproof.

Mr. HELMKAMP—I doubt if it would stand some of the winds in Kansas.

Mr. REED—A wall could be designed to withstand the wind pressures. Wind pressures are not as great as explosion pressures.

Mr. BRADY—You could make it of solid concrete, could you not?

Mr. PRICE—I think a more practical construction would probably be a medium between the very thick construction of the present and what we are considering here.

Mr. HELMKAMP—In connection with this thin construction on the working floor, the Murray elevator at Kansas City is being constructed with that in view. They also have the tunnels equipped with five vents, one at each end and three between the bins.

Mr. FRITZ—I have taken quite an interest in your discussion of the explosion at the Murray Elevator. Two years ago this month I was working at the elevator, conducting investigations relative to the invisible loss occurring in dried corn. Part of our work was to detect, if possible, the amount of loss that occurred in handling corn in the house, that is, loss that could be accounted for as dust. As a part of our work, we decided to try to determine the amount of dust that collected per square yard on each floor for the duration of twenty-four hours. It was deemed advisable to leave the customary number of doors and windows open on each floor. A square yard of paper was placed at different places on each floor and allowed to remain there for twenty-four hours. At the end of the period the collected dust was weighed and recorded. It was found that there was a more or less regular increase from the scale floor to the ground or working floor. The point I wish to emphasize is that this substantiates the recommendations of the gentleman who

just talked to you concerning the advisability of having numerous windows and doors in the future elevator construction. The scale and garner floor of the Murray Elevator had many windows as did some of the intermediate floors. When these were open most of the dust was carried out by the air currents and only slight effort was necessary to brush the sills and girders. On the working floor the situation was entirely different. There being fewer openings, the dust could not escape as freely because of the lack of openings to allow air currents to pass through and consequently most of it settled on the beams, floors, etc.

Mr. PRICE—The explosion in the Murray plant started down in the basement where the large quantity of dust was present.

Dr. BROWN—I would like to hear some discussion on the question Mr. Reed brought out, of extending elevator casings out through the roof. My reason for interest in that is that I made that as a possible recommendation in the case of the rebuilding of the Port Colborne elevator.

Mr. BRADY—A construction of that nature is now being used in some of the oat plants, as I understand it. A cereal company in the Middle West are capping the legs in their plant. They have had some explosions in these legs since they capped them. The cap would blow off and not do any damage to the plant.

Mr. HIBBARD—The Milwaukee explosion took place on the main floor and the elevator was constructed of steel plates but the explosion was so strong that it blew the plates out and tore the bolts out and they had another explosion at the top.

Dr. BROWN—That would be a question of pressure and velocity developed. With the most inflammable mixture of dust and air probably the pressure exerted upward would overcome the air pressure and the inertia in the dead air would be so great that the side walls would blow out and not overcome the hazard.

“LATEST DEVELOPMENTS AND DEVICES FOR PREVENTION OF CHOKES IN ELEVATOR LEGS.”

By MR. P. E. BRADY.

Choke-ups in elevator legs occur frequently. The four common causes for such occurrences are: (1) Overloading; (2) Bins becoming full; (3) Belt plugged by foreign material; (4) Power going off.

The over-loading feature is generally caused by a mechanical defect in that the belt and cups used to carry the load away from the boot are sometimes too small to take care of the incoming grain. Conditions of this kind do not often take place, but in some instances these facts have been brought out. One instance of this developed during an investigation of a dust explosion which occurred in a large starch factory in this country. It developed that this company was using a large conveyor which emptied into an elevator boot and elevated through a leg. When this conveyor was loaded to full capacity the boot or leg was not of ample size to take the product away. Consequently a man had to be employed to gauge the flow of the material in the conveyor and it was his business to see that this conveyor was never loaded to a degree whereby it would choke the leg. Of course, such conditions are most inefficient as well as dangerous. At times it was known that this man had permitted the conveyor to be over-loaded and thus a choke occurred in the elevator leg. This kind of an occurrence could be remedied by putting in the proper sized leg and cups to elevate the material which might come from such a conveyor when the conveyor was run at full capacity. Defects of this nature can be remedied by proper mechanical installations. Such occurrences do not take place frequently in the average mill or elevator, but mention is made of this fact to show one of the causes of choke-ups.

At times a choke-up occurs when the bins become full, the spout leading to the bin backs up into the elevator head, causing the grain to back-flow into the boot. This is one of the common causes of elevator choke-ups, especially in country elevators. The average country elevator is run by one man and he does not get up to the top of his house as often as might be expected. Consequently he is not always familiar with the amount of grain in the bins. He invariably is very busy and sometimes these bins become filled up. The spout leading to same fills up and eventually the grain starts to run down the elevator leg and a choke-up occurs. There are two ways for eliminating these occurrences. The first is by putting in a bin alarm system. This consists of a device which is attached to the top of the bin. When the bin becomes filled with grain this device automatically gives a signal warning. It is operated by electricity and the warning is given by the ringing of a bell on the work floor. Another way to overcome a choke-up is by placing what is called a signaling distributor on the spout which leads to the bin. As the spout fills up it chokes back into the distributor, or, in other words, an

overflow device. This overflow may be emptied to a floor or any suitable receptacle. The operator can easily see this falling grain in most any part of the work floor, or hear it rattling down the tube, when he immediately shuts off the grain and the flow-age stops. He then shifts the spout to another bin. Various turn-heads or overflow signaling devices are on the market, all of which are working to a fairly satisfactory degree.

Sometimes the return spout, the non-chokable head, is run into a relief chamber. When the bin is full the return spout discharges into the relief chamber which fills to the point where the downward pressure equals the sidewise pressure in the supply spouts, thereby shutting off the supply of grain. This feed will handle any kind of grain and prevent chokes from over-feeding.

Another automatic shut-off for an elevator leg is also in use. When the spout at the head of the elevator has filled to an overflow, the grain then runs down into the balance cylinder. The weight of the grain bears this cylinder down and automatically closes the gate in the elevator boot, thus stopping the flow of material into the elevator. An electric signaling device is sometimes attached so that a bell rings when this cylinder becomes filled and moves its normal position.

Sometimes sudden shut-downs in elevator legs occur. This happens when the cups are full of grain. This results in a choke-up, back-legging causing it, that is, the belt starts to drop down instead of going up. Back-stop devices have been brought out which operate automatically, immediately acting as a brake on the head pulley when it starts to revolve opposite to the way it is supposed to run. This is simply an automatic brake device. Various kinds are used and arrangements of this kind should be encouraged, as choke-ups are caused frequently, especially on electrically-driven legs, by what is known as back-legging.

It appears that more research work should be done along the lines of providing better equipment for the prevention of choke-ups in elevator legs. The average house today takes no precaution for such occurrences. The elevator contractors and construction companies pay little heed to devices of this nature, and it appears that some work could be done whereby these various concerns and engineers could get together and form some kind of a standard code with reference to equipment of this nature.

Mr. PRICE—This subject is a most important one since a large number of explosions have occurred from "choke-ups" in elevator legs.

Mr. DEDRICK—The point brought up by Mr. Brady in regard to the choking of elevators is one in which I am very much interested. An elevator can be choked down gradually as the result of a poorly constructed or defective elevator head discharge, or when by reason of too great a speed, the grain is discharged or thrown with such force that it strikes the forward end of the head, rebounds, and falls down the back leg.

A certain quantity of grain thus keeps returning over and over all the time the elevator is in operation, and in the course of an hour or two will become gradually overloaded and then choke down, unless the grain from the intake spout is shut off to relieve and allow the elevator to clear itself.

I have had elevators choked down simply by strings lodging on the tongue (a projection above the throat or discharge and between it and the back leg). They piled up so high that a stream of grain or other stock, discharged from the cups, would not wholly clear this obstruction and, meeting with this obstruction, would fall down the back leg.

When at such times grain or any other material falls down the back leg it induces air pressure within the leg and causes what is called "blowing," producing a great deal of dust which is emitted from any opening in elevators, spouts, etc. This "blowing" serves notice that something is wrong and that there is danger of a possible choke and stoppage of the elevator belt. The point of discharge, that is the throat, may be too high and cause more or less trouble and choking down.

I have had a few cases where I was called in to rectify the matter and found the throat was up so high that the grain would not discharge properly; that so much grain would go down the back leg that perhaps in a half-hour's time or even less, the elevator would be choked down, unless relieved in time to avoid it, and then allowing the elevator to clear. The method of relieving the elevator and preventing a choke down when the discharge spout is filled or clogged up at the head, by allowing the grain to flow down a spout the opening of which is above the clogged point, and this relief spout led to a point into the intake spout at boot and just ahead of it, so that the returning grain will flow in ahead and cut off the original feed, thus allowing the returned grain to make the round over and over until the clog at head is cleared, is very good indeed. However, I think the best method is to have an automatic arrangement in which the feed is cut off entirely, that is, the grain from the release spout at the head flowing into a receptacle or pivoted box that under a

given load or weight will operate a lever or series of levers connected to the slide of intake spout and close it, allowing the elevator to clear itself of all grain, the box being large enough to accommodate the excess grain. I think slides could be thus arranged to be closed automatically the same way, whether the grain is led into the boot at front, back or side.

The choking down of an elevator is, I think, one of the most dangerous features for causing fires and possible explosions in a grain elevator, flour mill, or any cereal plant. I know of a number of cases where the choking down of the elevator has started fires.

Mr. PRICE—Now you men have been in many plants the last few years, and I am very desirous to know if you have been in plants where they have installed any of these devices, or something similar. If so, which is giving the best results that could be obtained in connection with choke-up troubles.

Mr. WITMER—In the new Pennsylvania Railroad elevator at Baltimore, which is under construction and not yet in complete operation, they have a device installed which is supposed to take care of the elevator going back, or a back stop. The elevator has not as yet been tried out sufficiently to say whether it will work successfully or not. They have only run about 100,000 bushels of grain in order to try out the machines. I have been told that when this plant is completed it will not only be the largest grain elevator on the eastern coast, but will have the latest and best equipment obtainable. In other words, the last word in elevator construction.

Mr. HIBBARD—In the new plants that are built in the west they have separate motors, and when a choke occurs in the elevator it breaks a circuit and throws the motor off.

Mr. PRICE—We understand the Public Elevator at New Orleans has been using a device of this nature.

Mr. BROWN—I do not recommend this installation at this time. I understand from Mr. Sanford, the superintendent, that it is his own invention and he is endeavoring to get a patent on it. I can give you a brief description of the system. The elevator is run by one motor and the conveyor carrying grain to the elevator is run by a separate motor. An idler pulley on the elevator belt is connected to a steam engine governor. In case of a choke, the elevator belt slows down; at the same time the governor drops and breaks the circuit to the motor running the conveyor which carries the grain to the boot of the elevator. In this way,

before the elevator belt has had a chance to stop or choke, the grain being carried to the boot is stopped and prevents the boot being filled. This elevator also has a stop at the top to prevent the buckets running down and carrying grain back to the boot. As soon as the trouble has been remedied, the elevator is started again. In fact, it must be started before this automatic contact is thrown in by the governor. As soon as the elevator is again in operation, the belt conveyor can be started and the grain elevation continued as before. I do not know whether I have made myself clear on this matter. This installation, I believe, is the only satisfactory installation that I know of in the country and is fool-proof.

Mr. RILEY—In regard to the non-chokable leg mentioned by Mr. Brady, I wish to state that I visited this plant and saw this leg in operation and I understand that it has been in use for some time and is giving satisfaction. Housed in at the back of the leg, just below the spout leading from head of leg, is a metal bucket held in position by a weight or counter-balance attached to bucket by a short piece of bell-cord, this cord passing over a small pulley placed at one side of leg. This weight or counter-balance exceeds the weight of the bucket by fifteen pounds. The bucket is attached by steel cable to tension pulley of belt drive, driving screw conveyors that convey grain to leg. If the bin that leg is discharging grain to becomes filled, and grain flows back into leg from spout leading to bin, this bucket receives it and as soon as weight of grain in bucket exceeds weight of counter-balance, bucket drops down and automatically draws tension pulley away from driving belt of screw conveyor that conveys grain to leg, allowing driving belt to slack and thereby stopping conveyor. Stopping of conveyor automatically shuts off flow of grain from spouts leading into conveyor, as these spouts lead into the side of the conveyor instead of to the top as we usually find them. The capacity of this bucket is approximately 600 pounds of grain and this grain passes out through a three-inch hole in the bottom of bucket where it falls into leg and is carried to head of leg where it again falls into bucket and this continues until spout is set for another bin, when grain in bucket and leg is discharged into it and bucket automatically resumes its normal position.

Mr. PRICE—Mr. Riley sent a report to Washington regarding this installation and we felt that it was giving satisfactory results.

Dr. BROWN—Whenever we get a choke in an elevator, we get friction at the head, and I should like the opinion of some one as to the practicability or effectiveness of sprinkler heads in elevator heads to extinguish the fire, or to prevent excess heating which may result from a choke.

Mr. HIBBARD—It takes about 170 degrees Fahrenheit to open a sprinkler head, and by that time the whole plant would be on fire. The sprinkler head, as a rule, is set out at a side with an opening between. It is not directly over the pulley.

Dr. DUVEL—Would it not be possible to provide elevator heads with a thermo-couple adjusted so that when the temperature resulting from friction approached the danger point, the elevator would be stopped automatically. Such a device could probably be used in connection with or as a supplement to sprinkler heads. I appreciate that elevator foremen, in case of a choke, are frequently inclined to force the machinery in order to relieve the choke, but I believe in most instances, if they can be made to fully appreciate the hazard surrounding such procedure, they would prefer to stop the elevator and remove the cause of the choke rather than to take the chance of an explosion. This, of course, involves a long and tedious process of education.

Mr. HIBBARD—The sprinkler head has to be out of the way because if it comes in contact with the buckets it is likely to be broken open and flood the leg. That is why they set it out to the side with an opening into the elevator head.

Dr. BROWN—You can set it directly above the pulley, I believe.

Mr. McCOLLAM—In this connection I might call your attention to an installation in California. It seemed a very clean installation when it came to put out a fire. You might call them gas heads; that is, carbon dioxide tanks were attached to the elevator head. In case of fire the fusible heads were melted and the carbon dioxide flowed into the elevators and, of course, settled, being heavier than air, and put out the fire.

Mr. PRICE—The Pacific Coast has evidently tried the use of inert gases very effectively.

"A DISCUSSION OF THE RELATION OF GRAIN DUST EXPLOSIONS AS APPLIED TO FLAT-WARE-HOUSES AND ELEVATORS."

By GEORGE P. BODNAR.

I will try to tell as briefly as possible the relation between Flat-warehouses and Elevators with respect to Grain Dust Explosions as these types of grain handling houses appear to me from personal observation.

In the Pacific Northwest I had occasion to visit many Flat-warehouses that handled flour and grain stocks of the U. S. Grain Corporation. Most of the warehouses had cleaning-houses equipped with about the same type of cleaning machinery that is found in the ordinary elevator so that similar conditions prevailed in the former as were found in the latter kind of grain handling plant.

In warehouses without any grain handling or cleaning machinery, which fact implies the creation of very little or no dust as compared to the elevator, it seems to me that the chances of a dust explosion are very slight or remote. In case of a serious fire, a warehouse of the above type, handling flour, would have an explosion risk where one handling grain alone would not. The bursting of flour sacks piled as high as they are (have seen them as high as 13 feet at least) could very easily cause heavy dust clouds with the resultant explosion risk. The bursting of grain sacks under similar fire conditions would be unlikely to create enough dust for an explosion.

The cleaning section of the plants visited was usually found in about the center of the warehouse. The machinery, elevator legs, spouts, etc., are more or less exposed to the interior of the warehouse so that in walking through the warehouse much of the machinery is visible. It is the desire to consider these types of warehouses with respect to the following feature, that is, the amount of exposure of cleaning house above the top of the warehouse proper. The cleaning section of the first type is so open with respect to the interior of the warehouse that even though there is a sufficient quantity of dust accumulated on the spouts and other ledges to propagate an explosion, the explosion could hardly do much damage in so far as the demolishing and hurling of material by the force of the explosion is concerned, as would be the case were the machinery enclosed to the extent it is in an elevator.

The remarks made with reference to this cleaning house will

apply with equal force to the portions of the cleaning houses in the other two types that are below the roof of the warehouse proper and exposed to the interior of the warehouse. So far as an explosion is concerned about the same thing would happen in the parts of the cleaning houses above the roof of the warehouses as would happen in the ordinary wooden elevator that was dusty or had dust accumulations to propagate an explosion.

The cleaning house in the first type is not equipped with bins such as are found in the wooden or concrete elevator. The other two cleaning houses are equipped to handle or store grain in bulk on a small scale, (up to about 10,000 bu.) that is, grain received in sacks, after being cleaned, is held in storage for short periods. The arrangement for discharging the grain into the bins is the same as that of the elevator. Ordinarily the grain is resacked as fast as it is cleaned. When this is not the case the bins are used and there is therefore the same danger of an explosion in the bins of the cleaning house as there is in the bins of the elevator.

With respect to the bins and choke-ups in the elevators the same precautions therefore apply for prevention of dust explosions as apply to the elevator. With those we are familiar, so there is no need mentioning them at this time.

The cleaning section of the warehouses visited was rarely as high as the country wooden or concrete elevator of about forty or fifty thousand bushels capacity, and no manlifts such as are common in elevators were found. Consequently they have nothing that resembles that part of the elevator commonly termed the "well." Any explosion occurring in the bottom of the cleaning house could not travel up through a "well" as was apparently the case in a recent explosion in the Middle West. In my visits to elevators it was not unusual to find the "wells" of elevators pretty dusty compared to other parts of the plants. In case of the cleaning-house of the flat-warehouse it is therefore an advantage to have no "well" in which dust can accumulate to produce an explosion hazard.

A fire originating from a dust explosion (or from any other cause) in the vicinity of the elevator heads is more easily, or rather more safely reached in the case of the cleaning house than in the case of the grain elevator. The stairways of the former are arranged in the order they are in a flour mill of about two or three hundred barrels capacity. In quite a number of the elevators visited I heard operators declare that if a fire ever started in the cupola of their elevator, the fact that there was a sufficient fire

equipment in the top of the elevator, would not be an inducement to go up the manlift to the top to extinguish the fire. The objection seems to be the fact that the manlift is ordinarily supported by means of a fibre rope. The flash of a dust explosion could very easily ignite the rope and it would be consequently quite hazardous to attempt to put a fire out in the top of the elevator. A fire starting from a source other than a dust explosion would naturally create the same condition but probably not as quickly, depending upon the circumstances.

From the standpoint considered the elevator is therefore not as desirable as the cleaning house of the flat-warehouse. A suggestion pertinent here is: Equip elevators with the manlifts braced with metal and then supported by steel cables instead of fibre rope.

With one exception the cleaning houses in the flat-warehouses of the Northwest were much cleaner with respect to dust than either the wooden or concrete elevators taken as a whole, and consequently the explosion hazard was less, and will continue so providing the above condition remains true.

The points brought out in the above discussion are about as follows:

1. On account of the open style of construction of the section of the cleaning houses beneath the roof of the warehouse proper an explosion in the cleaning house at this floor would not result in as much direct damage from the explosion as would be the case in an elevator.

2. Flat-warehouses of the type found in the Northwest have the same danger of dust explosions in elevator heads, bins, and upper floors as the wooden or concrete elevator (when the cleaning houses are equipped with bins).

3. On account of the fact that the cleaning houses of warehouses have no "wells" common to elevators, explosions occurring in the former on any floor have no easy access to other floors, except through elevators and stairways if these are not closed by doors.

4. On account of the use of manlifts supported by fibre ropes the elevators present more danger when it comes to putting out fires in the cupola of the elevator than do the cleaning houses with fire at a similar point.

Mr. PRICE—Here is a chance to find out something about the Pacific Northwest. Are there any questions you would like to ask Mr. Bodnar?

Dr. DUVEL—If the elevator managers are aware of this danger I would think they would use a wire cable on the manlift or elevator instead of ordinary rope.

Mr. BODNAR—I have seen that arrangement in two elevators in Idaho. In the elevator at Moscow, Idaho, the manlift is equipped with a wire cable about three-eighths of an inch in diameter, which is quite flexible and serves the purpose I had in mind.

Dr. DUVEL—It seems to me if they recognize they have that risk it would be one of the first things they would take care of.

Mr. BODNAR—I went into an elevator and found a fire extinguisher on the top floor only. It had not been in use for years. The operator said if they had a fire in the basement he wouldn't run up to the top floor to get the fire extinguisher, or in case of a fire in the cupola he would not go up to attempt to put the fire out.

Dr. DUVEL—I suppose that was for the benefit of the insurance company?

Mr. PRICE—Are there any further questions on the discussion of the flat-warehouse matter?

Mr. REED—I would like to ask a question. Are the cars loaded by means of sacks or is the grain shipped in bulk?

Mr. BODNAR—The grain is shipped in bulk and sacks to the mills on the coast and is ground there. The coast is learning to handle grain in bulk more and more than it has been doing, and it is just a question of time when they will not handle any more in sacks. In my recent visits to the country I noticed many new concrete elevators in the course of construction. These certainly are signs of the breaking away from sack handling of grain in favor of the bulk method.

“EXPERIENCES THAT HAVE BEEN HELPFUL IN MAKING INSPECTIONS.”

By MR. G. A. HIBBARD.

In making inspections of the mills and elevators in Wisconsin, Illinois, Michigan, Indiana and parts of Kentucky it has been my fortune to come in contact with varied types of managers and superintendents. Some of these were very skeptical, especially the man who has been in the business for a great number

of years and having no accidents. The other class were those who, having read about the dangers from dust explosions, were anxious to co-operate in every way possible to prevent them.

It is with the first class of men, or the skeptical ones, where I have received the most opposition, that I have been able to accomplish the most good. The same has been true in my own case, as I was keen to see any defects or conditions in the plant to prove my argument and bring home to the operator the serious condition that existed.

I have in mind one superintendent of a large elevator in particular in Chicago, who has been in the business practically all his life and was pensioned by the operator, but is still handling one of their elevators. When I made my first visit to the plant, while giving a demonstration of a small explosion and a short talk to the men, the superintendent did not regard the dust situation as serious. He showed me every courtesy possible. It was not until after the explosion at the Murray elevator in Kansas City, when I returned to this same party and was giving him a few details of the explosion and showing him a few photographs of the destruction wrought by the explosion, that he finally acknowledged the dangers existing from an accumulation of dust. In order to withdraw gracefully from the argument, he wanted me to understand that he had reference to an explosion caused by spontaneous combustion in the dust, which we know is impossible.

The most helpful experience that I have had was that following the explosion at a feed plant and elevator in Milwaukee, Wis., in May of 1919. It was a disastrous explosion, killing three men, injuring four, and causing a property loss of about one hundred and fifty thousand dollars.

The management thought that after erecting a concrete and steel plant they had taken all precautions necessary for their employees' safety as well as their own. They had overlooked the explosion hazard and had no appliances or system to take care of the removal of dust created in the handling of grain and feed materials in their plant. It was while I was making the investigation of this explosion that the management came to me and made the request that when the plant was rebuilt they would appreciate any help that we might be able to give them. Several months later they notified me that they were about ready to rebuild and desired to have me make recommendations as to the points at which suction should be applied and other explosion preventive measures to be used. These requests were complied

with and suction was applied to the elevator boots, elevator heads and to an expansion chamber on the screw conveyor which received material from the attrition mill. The other safety measures installed were a choke valve in the screw conveyor holding back a certain amount of material at all times to prevent the spread of any explosion that might occur in the attrition mill or other parts of the system, and a release pipe leading direct from the screw conveyor to the outside to relieve any pressure that might be created by an explosion in the system.

About thirty days after this equipment had been installed an inspection of the plant was made and it was found in the very best of condition; the suction system was collecting approximately eight grain sacks of dust and fine material per day, which, without the suction system, would have been scattered throughout the plant creating a dangerous condition and requiring considerable labor. Where we find a dusty condition existing in a plant it is usually laid to the scarcity of help.

One other experience noted in a Chicago elevator helps to prove that a dust free elevator or plant is practically explosion proof. It was in the evening just following the closing down of the plant when fire was discovered on the distributing floor of the elevator. An alarm was turned in and on the arrival of the fire department the fire was quickly extinguished with a very small fire damage. Upon investigation it was found that the fire originated from an overheated bearing on one of the rollers underneath the distributing belt. It was communicated to a wooden frame work and from there to the cleaning machine, which was mostly destroyed by fire. Previous inspections showed this plant to be in very good condition and it is probably due to this fact that there were no explosions causing heavy losses.

Mr. PRICE—It may be that the men who have made inspections have had experiences somewhat similar to those referred to by Mr. Hibbard and we have sufficient time for discussion of this subject, or any other subject taken up this afternoon.

Dr. BAILEY—I take it as the consensus of opinion that when a series of bins occur in a plant it is advisable to cover the bins and vent them through the roof with a steel or galvanized iron vent suitably capped.

Dr. BROWN—I made that suggestion at Port Colborne.

Mr. McCOLLAM—May I add that it seems to be the general tendency in modern elevator construction, as far as I have

observed, to use natural ventilation as far as possible? I will call your attention again to the elevator in Ogden which has no dust-collecting system to speak of at all. The garner and scale hopper are both vented by means of a very large vent to the open air. This is supposed to take care of the dust hazard.

Dr. BAILEY—Each one of these bins should have its own distinct vent.

Mr. HELMKAMP—I have run across some elevators in which the conveying belts seem to be pretty close to the floor. It would seem that if they would raise these belts possibly six inches it would be easier to sweep out and this change would not incur much additional expense.

Mr. DEDRICK—The venting idea is good. I think the same results could be accomplished by a suction system and dust kept within certain limits and from getting out of machines, spouts, elevators and other openings. The suction would pull the dust out and away from bins, elevators, etc., at once, without allowing it to float within the building. The fan drawing the dust should exhaust into dust collectors, preferably outside the building.

There should be direct suction at every point where, in the course of operation, dust is made, and liable to escape and to spread throughout the plant. For instance, I would carry a suction trunk with a hood right up to the car door and over the dump grating. This would take a great deal of dust right at that point, and leave that much less to be contended with after the grain entry in the elevator or mill. In the ordinary elevator much of the dust made at the unloading chute blows into or enters the building.

This can be accomplished by having just enough suction to pull nothing but the light floating dust away and keep it moving toward the hood. The elevator heads might be built higher beyond the circle described by the moving belt and cups, and there at the top, at discharge end, instead of the ordinary suction spout with its small opening, have the suction spout opening extend the full width of top and back a ways. This could be accomplished by flaring the spout so as to cover this opening. This would give more spread or surface to the drawing current, at the same time weakening it so that it would be less liable to draw good material with the dust, as happens with a small opening with a concentrated current that draws more heavily at the point where the grain is discharged as the belt and cups move

over the head pulley. To avoid any possibility of good grain or material being drawn up, baffles may be placed inside the elevator head below the suction spout opening and the discharged grain thrown in a spray, thus preventing a direct current acting on the grain.

At the trip is another source of much dust. This dust can be taken care of by placing a suction hood over the point of grain discharge. A suction trunk should extend the whole length of the elevator bins and tanks. Stubs would allow of making connection with a trunk attached to the trip that extends on both sides of trip over the bins on each side of the gallery or belt carrier. To the ends of the trunk, hoods (inverted cones) could be attached, one on each side of trip. These hoods need be only part size of the open bin, but placed somewhat above the open bins. The suction current should be strong enough to draw the dust as it arises from the bin when being filled, and thus keep the dust within that zone or area until it reaches the hood.

This idea can be carried out on the working or unloading floor, by having the unloading carriage movable like the trip, with a hood over it to be attached to a main suction trunk overhead, similar to the one at the top. A hood should be placed at the discharge end of belt also. Suction should be applied at the elevator boot, between the legs. The main thing, I think, is in the first place to avoid, if possible, the making of dust, and, secondly, to remove such dust as is made and liable to escape and float about the building, as quickly as possible at the various points. It does not make any difference as to the kind of building construction, whether wood, iron, steel or concrete—dust is a menace to all alike. A concrete or steel constructed elevator or plant may not burn down, but it can be wrecked by a dust explosion in the twinkling of an eye. It seems like the height of folly to erect costly steel or concrete elevator plants with the one idea of preventing destruction by fire, and then to make no adequate provision for preventing the making of dust or its escape into and diffusion all through the plant, and thus having the even-present possibility of a disastrous explosion.

Mr. BODNAR—In connection with Mr. Hibbard's paper, I desire to refer to the general cleanliness of plants in the Northwest. They believe on the Pacific Coast that the climate has something to do with preventing explosions, inasmuch as they have never had any, but I have set off, in demonstrating explosions, much of their own dust, even on extremely wet days,

and I cannot see why they feel that they will never have an explosion. In some of the plants they seem to be taking modern precautions, and still they feel that the climate is keeping them from having explosions.

Mr. PRICE—It would be advisable for them to adopt additional precautions. The large number of thresher explosions in that territory were due to unusual climatic conditions. This would indicate the possibility of explosions in mills and elevators.

Is there is no further discussion, we will adjourn until tomorrow morning.

FRIDAY MORNING SESSION

April 23, 1920

Dr. J. W. T. DUVEL, Presiding

Dr. DUVEL—A few years ago, if you talked with mill operators as to disturbances or dangers attributed to static electricity, they were of the opinion that your arguments were based on some fanciful theory. Conditions have changed very largely in recent years. I am sure I am not overstating the situation when I say that this difference in viewpoint is due largely to the work that has been done by the Department of Agriculture and the Grain Corporation along dust explosion prevention lines.

The first paper this morning will give us some definite information on static electricity in attrition mills and methods of removal, as based on observations and investigations by Mr. McCollam, who has been in charge of our dust explosion work on the Pacific Coast.

“STATIC ELECTRICITY IN ATTRITION MILLS AND METHODS OF REMOVAL.”

By M. E. McCOLLAM.

Mr. McCOLLAM—Mr. Chairman: I have been assigned the subject “Static Electricity in Attrition Mills and Methods of Removal.”

Charges of static electricity which may be built up in attrition mills are of interest to us chiefly as a possible cause of grain dust explosions. There has been much doubt as to the power of static electrical discharges to ignite dust and cause fires or explosions. Some of the many interesting questions arising in this connection are heat and duration of sparking, leakage, insulation by some substances, such as oil films, and humidity conditions as

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affecting a high potential in an attrition mill. Experimentation has resulted in difficulties being experienced in igniting dust with static discharges, and no fires or explosions resulting from static could be obtained in an attrition mill. However, the experiences of myself, as I will describe later on, have pointed to quite a real possibility of danger from this type of electricity in attrition mills. Of course, fires and explosions have taken place in many attrition mills, but the cause has been assigned, generally, to foreign substances going through the mill and striking fire. Such materials may be stones, nails, pieces of metal, etc. Static electricity as a cause has been generally depreciated.

In treating this phase of the subject, we may say that the explosion is secondary in the case of an attrition mill, and it is usually the fire originating in the mill which starts the trouble. This fire spreads to dusty spouts or bins which are connected with the mill and an explosion occurs. Sometimes the fire spreads rapidly and an explosion occurs almost instantly, and at other times the fire smoulders for some little while, the explosions occurring later on. There are three possible causes of fire starting in an attrition mill. These are: First, hard metallic foreign substances going through the mill and striking sparks; Second, frictional heat caused by grinding certain materials may cause combustion to start, especially under conditions of over-feeding if mill has no vents to complete the air circulation; Third, sparking or discharge of static electricity over an appreciable period may ignite the product being ground in an attrition mill. This latter means is the one with which we are concerned most at this moment. Most of the static electricity in a direct connected attrition mill is generated by the action between the grinding plates. It is questionable whether there is any static generated at all by the induction motors driving the mill. In case of a belt driven mill, there may be quite an appreciable charge on the belt building up a potential in the mill.

For the most part, it is my intention to describe the details surrounding a series of seven explosions which took place in an attrition mill during the period of one week in the cereal mill of the Sperry Flour Company, at Stockton, California. Some of these explosions occurred on the same day. The most violent explosion of the seven was one which resulted in the elevator leg to which the mill was spouted being damaged. A wooden safety vent at one side of the leg was blown off, as was also the elevator head. Opinion was expressed that an explosion could easily have been caused throughout the plant had it not been clean and

free from dust accumulations, and this is probably true. The attrition mill in which the explosions occurred was ball-bearing and directly connected to induction motors. It was used for grinding oat hulls expressly. From a huller the groats and hulls fell to an air blast which was used to separate these two products. The hulls were blown over into a chamber which was spouted to the attrition mill. The groats being heavy fell by gravity into a separate bin. The significance of this is that any heavy foreign substance would have fallen into the bin with the groats and would not have been carried over to the attrition mill. As an added protection, the mill had the usual magnetic separator before it. The mill had no choke conveyor beneath it and was spouted directly to an elevator. After the first few explosions, the miller assumed that since it was practically impossible for any foreign material to get into the mill, the cause could be traced to static electricity. He took some pains to prove his assumptions, and did it very conclusively in his own mind. First, a gold-leaf electroscope was procured and various parts of the particular mill were tested. Violent positive deflections were noticed when parts of the frame were touched, and none at all, or what the miller thought were negative deflections, when the shafting was touched. What was probably more convincing and certainly more spectacular, was the next step taken by the miller. He cut a piece out of the plate housing of the mill and inserted a piece of glass through which he could watch the inside of the mill. At the instance of the most violent explosion, the miller was watching sparks jumping from the grinding plates of the mill. The sparking was intermittent at first and then continuous. The sparks seemed to be streaming around the outside edges of the grinding plates. Almost immediately after this last occurrence the explosion took place in the elevator leg. The miller particularly noticed the color of the sparks or "fire." It was the light blue, characteristic of static electricity. The miller was convinced that the explosions were being caused by static sparking in the mill, and immediately took steps to avoid future trouble. Not only this mill but all the attrition mills in the plant were grounded as a result.

The miller, in doing this, fully believed that all the charge could be led off by simply attaching the ground wire to the frame of the attrition mill. This method was employed, and although in my opinion it is not as desirable a wiring system as could be installed, the fact stands that no more trouble has been forthcoming in this plant since the grounding was done.

The reason for the effectiveness of this grounding method was due no doubt to the fact that the mill was a ball-bearing one, and it is here that we must turn to a consideration of the relation of types of bearings on an attrition mill to the passage and storing up of static charges. Even though a ground wire is led from one point of contact on the frame of a ball-bearing attrition mill, it is possible that this may suffice to lead off all of the electricity. The principle of lubrication of a ball-bearing machine is entirely different from that of an ordinary box-bearing. There is always a certain point on one of the balls which is in contact with both the shaft and the housing, so that no insulation is offered to the passage of static electricity. A lead from the frame of the machine could therefore take off charges from all portions of the mill. An ordinary box-bearing is lubricated differently, the object being to establish a permanent film of lubricant between the shaft and housing. This acts as an insulator and an electrical charge will not pass if the lubrication is perfect and a complete film established. So that a mill with this kind of bearings would not be relieved of static simply by a lead from the frame, since this lead would not be taking the charge from the shaft to which the grinding plates are attached, and to which, in the case of a belt drive, the pulley is attached. It would be necessary, therefore, to take leads from contacts on both frame and shaft to insure complete removal of static charges.

While the conditions under which static may be generated and stored up in an attrition mill may be rather complex, arising from kind of material being ground, rate of feeding, humidity of atmosphere and possible leakage, and the kind of bearings and drive on mill, the method for removal of this type of electricity is very simple and effective. Nothing more will be said about it other than describing one wiring method found to be quite effective and treasured in a large cereal mill in Oakland, California. Two attrition mills in this plant had been the seat of numerous fires, even though equipped with magnetic separators. This trouble went on for months with regularity, and the installation was about to be removed, when the mechanical engineer decided upon static electricity as the cause of the fires. He placed a brush on the shaft of the mill and made a contact on the frame of the mill, letting the wire from this brush make a contact on the frame of the mill. He laid a wire from this contact to a contact on the choke conveyor. An insulated wire was used in wiring the machinery, while the ground wire, or the wire leading to the ground through a water pipe, was naked copper

wire, with, of course, no sharp angle turns in it. I think there were two turns in the wire, both of which were very gentle turns that led from the contact over to a copper band around the water pipe, which was first well scraped to insure good contact. That is all there was to it. After he made that installation the trouble in the mill stopped. This may be a coincidence, but it points strongly to the danger of static charges in mills of this type.

Some conclusions which I have drawn from the series of explosions in an attrition mill at the cereal plant of the Sperry Flour Company at Stockton, California, which I have already described and which, of course, are open to discussion, are as follows: First, static electricity is generated in large quantities at times in an attrition mill. Second, static electricity may ignite ground oat hulls or oat hull dust, causing fires and resulting explosions, but to do this the discharge must extend over an appreciable length of time. Third, effective methods of wiring must involve a study of the possible paths of electricity and insulating mediums, and leads should be taken from all parts insulated from one another.

The film of oil between the shaft and housing of an ordinary box-bearing is an insulator preventing the passage of static electricity, but such a condition does not exist in the case of a ball-bearing mill.

The purpose that I have hoped to accomplish at this moment is to draw attention to the occurrence and results of static electricity in the attrition process of milling. I wish to emphasize my opinion that static electricity may cause fires and resulting explosions, and that it is a sensible precaution to remove static charges from all machinery in a plant, and especially from an attrition mill.

Dr. DUVEL—We have this very interesting subject presented by Mr. McCollam for discussion. I am of the opinion, however, that it will be desirable to have Mr. Roethe's paper first and discuss them both at the same time. They are closely associated, and if handled in this way will save time, and no doubt avoid repetition. There being no objections, I will ask Mr. Roethe to present his paper on "Recent Investigations of Static Conditions in Industrial Plants."

RECENT INVESTIGATIONS OF STATIC CONDITIONS IN INDUSTRIAL PLANTS.

By H. E. ROETHE.

- Mr. ROETHE—Mr. Chairman: Upon the completion of the threshing investigations in the Pacific Northwest in the summer of 1919, an opportunity was afforded to make a study of static electricity in representative mills and elevators. The electrical equipment used in the case of grain mills and elevators consisted of an Albrecht type voltmeter, a six-cell Murdock condenser, a spheregap, and a galvanometer taken from an ordinary electrical resistance thermometer. The investigations continued from August 22d to September 12th, which allowed only a limited time at each of the plants. The plants included were the Sperry Flour Mill of Spokane, the Fisher Flour Mill of Seattle, the Sperry Mill of Tacoma, the Albers Milling Company plant at Portland, and also the Portland Flouring Mills and the Crown Flour Mills of Portland, the Washburn-Crosby "A" Mill, the Northwestern Consolidated "B" Mill, the Northwestern Consolidated "F" Mill, and the Northwestern Consolidated Elevator, all at Minneapolis. Incidentally the last named elevator was the only one in operation in the cities visited, so we could get no results of tests conducted at this time in any other elevator. I wish to emphasize the fact that the results obtained were not extensive enough to establish any permanent or definite conclusions regarding production of static charges in grain mills and elevators. However, we hope that the results obtained were at least of some value.

The general procedure was to start on the top floor of each plant visited and take the different machines or series of machines in the order that they were reached. Leads from the voltmeter, spheregap and galvanometer were run to the different machines, and a study was made of static charges found on each part of the individual machines, and on the machines as a whole or as a unit. The ground wire in each case was run to a water pipe, or similar pipe, to insure effective grounding. An effort was also made to study the relation of the different parts of the machine to one another. For instance, it seemed advisable to secure information regarding the difference of potential between the roller on the roller mill and the frame of the machine itself. I give that as an illustration to show that we desired to obtain results showing the difference of potential between the different parts of the machine itself as well as between the various machinery and the ground.

Considerable rain was encountered in the Pacific Northwest, in Seattle in particular, consequently the readings secured there were not great, due to the high humidity. Generally the thermometer readings in the Pacific Northwest ranged from 65½ to 75 degrees Fahrenheit, and the relative humidity from 22 to 60 per cent. While in Minneapolis the fore part of September, we found the temperature ranging from 72 to 82 degrees Fahrenheit, and the relative humidity ranging from 34 to 40 per cent. This shows that the readings of humidity were higher and also of a greater range in the Pacific Northwest than at Minneapolis.

I might just make a few statements regarding positive and negative electrification, because in giving the results obtained reference is continually made to these terms. The theory is generally accepted that all bodies have upon them a natural amount of electricity which cannot be detected owing to the fact that all bodies have a similar amount. However, it is possible to redistribute this natural electricity. Since it is always necessary for two bodies to be electrified at the same time and with opposite electrifications, it is apparent that rubbing or friction effects the redistribution of this electricity which existed upon the bodies in its natural state. It is also evident that one body acquires more than its normal amount of electrification, and the other body loses some of its normal amount. There is, therefore, only one kind of electricity, but two kinds of electrification: one produced by an excess of electricity upon a body, and the other by a deficit. The sign "positive" or "plus" indicates that a body has more electricity upon it than is natural or normal, and the sign, "minus" or "negative," that it has less than its natural amount. When a positively charged body is brought in contact with a negatively charged or neutral body, a flow of electricity takes place, electricity passing from the positively charged body to the other.

Rather than give the detailed results obtained at each plant I will summarize the readings made at all the plants visited. We found violent positive deflections on the suction pipes of unloading systems in which grain was being unloaded from cars. We also found 100 volts on these pipes. Workmen informed us that on hot dry days violent charges were found on these pipes when smutty wheat was being unloaded. This is in line with results obtained in similar tests on the discharge pipes of suction fans on threshing machines, where very violent positive deflections were recorded on the fan casing and discharge pipes. This indicates very strongly that the passage of dust, particularly

smut dust, electrifies the metallic pipe. In the case of threshing machines we have also found positive electrification on the grain pan over which the threshed grain passes, positive electrification on all parts of the elevator, and also on an aspirating system which was installed on one separator. In other words, the passage of grain and dust over a dissimilar material, such as a metallic surface, produced electrification. Generally, we found that a metallic surface was positively charged, and the material passing over it was negatively charged.

In the case of drive belts, large charges were always found on practically every belt, the charge depending upon climatic and operating conditions, the size, speed, material and slippage of the belts themselves. A maximum of 75,000 volts was found on a leather drive belt in one mill on the Pacific Coast, running from an electric motor to the main shaft in the basement. The belt was 22 inches wide and moved at a high rate of speed.

Conveyor Belts—Tests were made both on troughing belt conveyor rolls and flat belt conveyor rolls. Conveyor belts do not travel at what we would term great speed, generally moving at the rate of 750 feet per minute, or approximately $8\frac{1}{2}$ miles per hour. The slippage and friction is not apparently great on such belts. In a mill in the Pacific Northwest we found 45,000 volts on a rubber conveyor carrying smutty grain from the elevator head to the distributors on the top floor. A similar belt in the basement of the same building gave a reading of only 200 volts. Grain from the same car was being conveyed at the time tests were made. It is very probable that the belt in the basement, which was conveying the grain from the nearby car, was more directly or effectively grounded than the belt on the seventh or top floor, although the entire building was of concrete and steel construction. There is a possibility that the grain, which was smutty, was charged during the process of elevation with static and transmitted a large part of it to the conveyor belt above the bins. No voltage was found on canvass conveyor belts.

Elevator boots, legs, heads and spouts—We found no deflection or voltage on the boot in any mill or elevator inspected. We found no voltage, but a strong positive deflection on the legs; no voltage, but violent positive deflections on the heads; strong negative deflection on the spouts.

Separators, scourers, etc.—Next, coming to the receiving and milling separators, we found no voltage or deflection in any case.

On the scourers a maximum of 1,500 volts was found on the

fan shaft, a maximum of 2,500 volts on the discharge pipe, and a strong negative deflection on the fan shaft and discharge pipe.

No voltage was found on tempering mixers; strong negative deflection was recorded on the horizontal spirals conveying wet wheat; none on spiral conveyors moving dry wheat.

No voltage or deflection was found in the magnetic separators with the exception of the magnet.

In the roller mills, no voltage was found, but a strong negative deflection was found on the feed rollers and also on the rolls.

No voltage or deflection was found on the scalping and centrifugal reels and flour dresser. The same can be said for sifters, including plansifter and bolter.

No deflection or voltage was found on middlings purifiers.

No voltage, but violent negative deflection was found on bran and shorts dusters.

In the case of the Williams grinders, every part was violently charged with electricity. We found a negative deflection on every part, and 1,500 volts on the shafting and casing.

On the blower fans no voltage was recorded, although on one or two occasions we found a violent negative deflection on the intakes and discharge pipes. On several occasions a positive deflection was found on the fan casing, fan shaft, intake and discharge pipes.

No voltage was found on the tubular dust collectors, although at one time a violent negative deflection was recorded on the discharge pipe.

On the Cyclone dust-collectors a maximum of 250 volts was found on the drum and 500 volts on the intake.

The surprising thing in regard to the plants visited was that no effort was being made in any of the mills or elevators to carry off the charges of electricity produced. We feel that this should be done in the case of the large driving belts, scouring machines, grinders, elevator heads, blower fans, attrition mills and probably roller mills. In the case of belts, the charge can be very readily disposed of by means of belt dressing or a metallic comb. We found that the main drive belts, and those driving scourers and grinders, were always heavily charged regardless of existing conditions. The scourers should be equipped with a dry brush on the shaft, and wires should be attached to the discharge pipe and fan casing. It is surprising that more fires do not occur in scourers, due to the high speed of the machine and to the smut and grain dusts which are always present. We had no difficulty

in recording several thousand volts on every part of the scourers. In grinding machines, it is thought a dry brush should be placed on the shaft, and that wires be attached to the casing and discharge pipe. Here again large charges were always present on every part of the machine. In the case of elevator legs and heads, while no voltage was recorded, there was always a marked difference of potential existing between the elevator head and the ground. It no doubt would be advisable to attach a dry brush to the pulley shaft and a wire to the head itself. Static was often found present on the blower fan, on the casing, intake and discharge pipes. The dry brush should be attached to the shaft, and wires to the casing, intakes and discharge pipes. Mr. McCollam has made reference to the different types of bearings—including ball and plain bearings used on different machines operating at high speed. No doubt in case of machines using ball or roller bearings, it would not be necessary to attach a dry brush to the shaft, a wire connected to the journal itself probably being sufficient. However, to insure effective removal of any charges to the ground, it might be well to use the dry brush. Wires can easily be attached to the pneumatic unloading systems.

In closing, it is not at all easy to draw or form any definite conclusions regarding the study of static electricity in the elevators and mills visited, but the results show that, at certain times, dangerous conditions do exist on or in scouring machines, grinders, blower fans, and possibly the elevator head. Here conditions are most favorable for the generation of static charges, and an accumulation of them, and in these machines and equipment dusty conditions prevail. A hazard exists in the vicinity of rapidly moving large belts highly charged with static. This danger is all the greater in the case of arcs of static produced in a dusty atmosphere. A state of electrification exists on metallic tubing through which dust or grain is passing. The readings were greater in the case of smutty wheat or smut dust than clean wheat or grain dust.

Mr. McCollam has already discussed static electricity in attrition mills most satisfactorily, hence nothing further need be said regarding these machines.

Dr. DUVEL—We now have for discussion Mr. McCollam's paper on static electricity in attrition mills, and Mr. Roethe's paper on static electricity in general, just finished. Some very interesting points have been brought out.

Mr. PRICE—I can recall that early in this work when a dust explosion occurred, and we could not find the cause readily, that “spontaneous combustion” was usually assigned. In other words, it meant that nobody knew, in the lack of something definite, how these explosions did occur. A few months ago someone came into our office, I have forgotten just who it was, and said the insurance companies were no longer using “spontaneous combustion” but somebody had started the theory that always led them to believe that static electricity was the cause of these explosions. After the things we have heard in both of these papers, we have been given information which has always been looked for in connection with this subject.

Mr. McCollam states that in one of the mills in California, after a series of seven explosions had occurred, in the case of an attrition mill, that the superintendent actually observed large sparks of static electricity jumping from the grinding discs immediately before the explosion. I said yesterday we were trying for a long time to see a threshing machine explosion in the northwest and the difficulties encountered, but here the superintendent actually saw this explosion. I think that is remarkable evidence. Mr. McCollam sent that report to Washington a few months ago.

The results that Mr. Roethe has given us clear up the difficulties we had in the early days when determinations made in elevators and mills indicated the presence of static electrical charges. To my mind both of these subjects have been presented in a most gratifying manner, because they have given us facts, which have cleared up, beyond a doubt, the dangers existing in that direction.

MR. MCCOLLAM—In the Sperry Flour Mill, where the explosions occurred, the miller simply used the method whereby contact was made with the frame of the machine and the ground wire attached.

MR. PRICE—It appears that an arrangement where the static discharge had to pass through the oil film might not be as effective as the dry brush contact.

MR. MCCOLLAM—There were no explosions occurring after the grounding in either case.

MR. BODNAR—I think it would be necessary to conduct some tests to determine this, in order to prevent large maximum charges from passing through a small film of oil. It seems that a very small film would let a discharge go through. Of course I do not know how large a charge it would be. If oil insulates the shaft then use a dry brush on the shaft.

DR. BROWN—In that connection I might say it has been determined by the Bureau of Standards that a film of oil has ten times the resistance to the discharge of electrical current that ordinary air has. In other words, the resistance of oil is ten times stronger than that of air. It seems to me also that it is quite probable that a dusty atmosphere would have a tendency to aid in the passage of a discharge through it rather than to increase the resistance of the air. Now, going back to Mr. McCollam's paper. Mr. McCollam made the statement that he felt that there would not be an immediate ignition of the dust from a single discharge, but it was rather a question of a series of discharges over a short period of time through the same dust, and it took apparently a small amount of time to ignite the dust by means of the static discharge. That rather bears out one thing that I brought out at the last conference last year in connection with the condition of cotton. We found in making a series of tests at the Bureau of Standards that we could ignite cotton very easily with a static discharge, but that there were two or three controlling factors; that if we maintained a constant rate of discharge and started with a charge of low intensity, we would have to gradually build up the amperage before we could get any ignition; but then if we decreased the amperage on the static discharge, we could cut down the frequency of the discharge and still get an ignition, and so we obtained a point at which we could get an ignition of cotton very readily by simply one discharge, provided we had sufficient intensity or sufficient amperage on the discharge.

I might refer to another study of the subject I am interested in. As you probably know, we had no trouble in the northwest in igniting some dust on the ordinary static machine. We have not ignited any in the laboratory in Washington with a static spark. We have not tried it, but I happen to know that the Bureau of Mines have done a lot of work on that line. Of course, we feel that the use of an induction coil spark from an induction coil is slightly different from the static spark. On the other hand, we could control the ignition of the cotton in the same way by speeding up the action of the induction coil as we could with the static machine, and so I feel that the discharge is largely comparable. You may be interested to know that at the Bureau of Mines they have had no trouble at all in igniting some of their dusts by means of the induction coil spark which is comparable to the static spark, I believe by blowing, particularly gilsonite dust, against or over an induction coil spark. Gilsonite, some of you

may not know just what it is, but it is a mineral closely related to our asphalt.

DR. ALSBERG—I do not know very much about lubrication, but I have been wondering whether you can use graphite as a lubricant. Would not graphite act as a good conductor for electricity? I do not know whether such a lubricant or modification of it has ever been used, but I imagine it would act as a pretty good conductor. Of course we get good results from the dry brush.

MR. BATES—I have never heard of graphite being used in that kind of a bearing in the box. Graphite is used where heavy pressures occur, and where dust is apt to collect. A dry lubricant is used sometimes in connection with oil to add body to the oil. The theory of lubrication is that the adhesion of the lubricant to the shaft is sufficient, so that the speed of the shaft will draw the lubricant through under its weight and thus bear the shaft on a film of oil. This condition exists only at a speed and at pressures varying with the consistency of the oil. I believe that would be a very hard thing to produce in graphite. However, we are apt to think of perfect lubrication as providing a perfect film of oil, and we are apt to think that we can make the shaft in the bearing perfectly shaped. As a matter of fact, very few bearings probably are run at precisely the right speed and with the proper pressure to get perfect lubrication, even if you had a perfect cylinder running on a perfect cylindrical surface. Still it depends upon the speed and pressure, while as a matter of fact every variation of weight that occurs on your shaft is apt to change the angle of the shaft in the bearing, and you are very apt to find the shaft itself imperfect, so that every revolution of the shaft is not sufficient to draw in enough oil to give good lubricating effects. That undoubtedly accounts for the fact, as Mr. Roethe told us, that the voltage in many cases does not rise to an amount sufficient to show a deflection on some of the shafts by voltmeter of the static type; that is, the charge is similar on the moving part to that on the stationary part. Oftentimes we could not get readings. At the same time by using a galvanometer as a measuring instrument a very small amount of current affected the needle, making it spring. We were able to detect the presence of current, although the voltage was very small, undoubtedly due to the fact that the voltage was not allowed to build up, because at a certain low voltage it was neutralized through the bearing. That, by the way, was the meaning of the term that Mr. Roethe

used, "no voltage but a strong deflection." You could not have "no voltage and a strong deflection," because when taking the readings there must have been actual voltage, because no current could flow without voltage.

I wish to call your attention to a misunderstanding regarding this static electricity, as shown by the fact that Mr. McCollam said we must have as gradual curves as possible. The discharge of electricity or the detecting of electricity through a direct current is very well known, that is, it follows very direct laws, and we can predict and conduct current of that kind with a great deal of precision. As we get into the alternating current, the laws are varying, and up to the frequency of the ordinary 60 cycles we can predict what is going to happen. When we get to currents of extremely high frequency, such as you have discharged on alternating current, electricity violates all the laws. An alternating current would readily jump an air-gap in preference to following a coil wire, and for that reason you find electric light plants putting conductors of heavy copper wire on the outside of their buildings. We are taking the static as it is generated, and we do not have that frequency because there is no discharge through the air. When a spark jumps through the air it burns a hole through the air and becomes a good conductor, until it finally dies out, and we do not get that current as it is generated on these machines. Therefore, the best practice would be to put your wires where they are best protected, running them through any holes, in corners or any place, but have them well protected, and the angles will have no effect on the current. This is something we should understand, because if we attempt to make them place their wires in long smooth curves, we might get away with it all right so far as the millers are concerned, but some of the electrical engineers might view it with some reflection on our knowledge of electrical principles.

Mr. McCOLLAM—I might say in reply to that, with reference to the installation in the Oakland plant, that before making that wiring installation they asked the General Electric Company for any information they might have on the subject for wiring on static electricity, and the diagram they gave was followed out, and that was one of the special features in that plant—naked copper wire and the precaution against angle turns.

Mr. BATES—I certainly will have to admit that the authority is good, but I do not in the least alter my statement.

Dr. ALSBERG—I wonder whether I am correct in my understanding that you do not get any charges on canvas belts.

Mr. ROETHE—The only canvas belts available for tests were on conveyors. No voltage was found on these belts and no deflection, as indicated by the galvanometer.

Dr. BROWN—It has been suggested that graphite is used to a certain extent, and Mr. Price has some information on that.

Mr. PRICE—The information we have is more or less hearsay. I understand that a company in New York has made considerable progress along that line; just what it is I am not in position to say.

Mr. HIBBARD—It is just plain belt dressing to prevent slipping. Just what the composition is I do not know.

Dr. BROWN—What was the determination? Was the sign of the charge on the different belts negative or positive?

Mr. ROETHE—Generally we found positive sign on belts and negative on the metallic pulleys and idlers, although in some cases just the reverse was true. We secured no readings on the discharge pipes, although we did find that the pipes were apparently electrified to a certain extent because the chaff would adhere to the pipe in a vertical position. The chaff was blown out by suction fans on threshing machines.

Mr. PRICE—This stands out prominently in connection with what we have been trying to find out and have been doing. I want to ask Mr. McCollam now regarding this superintendent who observed this explosion. On what basis did he decide whether those sparks were not caused by the plates rubbing or by metallic substances passing through the machine? What satisfied the superintendent in his mind that they were electrical sparks, and not metallic sparks?

Mr. MCCOLLAM—The miller made no electrical determinations on the machine other than with the gold-leaf electroscope, and with this instrument he found very violent charges every time he touched the frame of the machine. He went throughout the plant and found other machines that had static electricity on them. This was the only method that he employed to base his assumption that the explosions were being caused by static electricity. He had made a study of static electricity and knew just what kind of a spark it made at the time of the most violent explosion. He was able to observe, in the housing of the mill, the color

of these sparks, and he called my attention to that very forcibly and said that proved in his mind it was caused by static electricity, and as I say, he mentioned the fact that the sparks were of light blue color, which is characteristic of the static spark, and I do not believe grinding plates rubbing together would produce sparks of that color at all.

Mr. BATES—I believe sparks which would be caused by abrasion or by something hard striking the rotating plates, would fly off at a tangent, while the electric spark would not be affected by the motion of the plate but would jump across the air-gap between the plates. Another way to identify the sparks is by the color. I have had thresher men state that on occasions when they threshed grain after dark, the cylinder of the machine was a perfect glow of blue fire. This indicates that there is often a continual discharge of static electricity at thresher cylinders, but that it is only the hundred millionth spark that occurs in just exactly the right condition to start a fire. Electrical discharges in threshing machines are dangerous only when the other conditions are favorable to make the explosion.

Dr. DUVEL—Is there any further discussion on this subject?

Mr. FOX, of the Edison Lamp Works—One point might be of interest regarding electric lighting. When going through a mill the ordinary electric light bulbs can be used to detect the presence of static electricity. The filaments in bulbs when burned near machinery charged with static electricity will be bowed out, and in some instances, especially in the ordinary carbon lamp, the filaments may be drawn to the edge of the bulb and cause it to crack or break. We found considerable difficulty along this line with certain types of lamps.

Mr. BATES—Would it be safe to use electric light bulbs next to a machine to detect a static charge?

Mr. FOX—I do not know just how sensitive this would be or how small a static discharge could be detected.

Mr. BATES—I have seen that tried on carbon filaments. You can take a carbon lamp and rub a rubber comb through your hair and draw the filaments almost to the side of the bulb when it is burning.

Mr. FOX—That was the trouble in carbon lamps, the filaments being drawn to the side of the bulb and eventually cracking the bulb.

Dr. DUVEL—There is one point which Mr. Roethe mentioned in his paper relative to tests for static on belts when handling different kinds of grain. I would like to ask if any of the men have made any tests of this character in the handling of flax. I think it is generally conceded that flax, after it has been handled, becomes electrified; at least, flax handlers find after handling flax through an elevator that the test weight per bushel is decreased sufficiently, frequently to cause the loss of a grade. There are probably two causes which play an important part: First, the roughening of the seed coat, which is normally very smooth, and permits the seed to pack well in the test kettle; Secondly, the question of electrification. In some experiments conducted at the Department of Agriculture, we took a test kettle filled with flaxseed and stroked, showing a test weight of 52 pounds. This seed was then placed in an ordinary Mason fruit jar and shaken slowly back and forth 500 times, then reweighed. On the reweighing the flaxseed more than filled the test kettle and there had been a loss in the test weight. This was repeated for an additional 500 shakes, still an additional 500, and still an additional 500, making in all 2000, weighings being made after each 500 shakes. In each instance there was an additional quantity of seed which would not go into the test kettle and also an additional decrease in the test weight. As I recollect, the final weight was 48 or 49 pounds, being a loss of 3 or 4 pounds. Whether or not this was due to electrification or merely to a roughening of the seed coat, I am not able to say positively, but it is probable that both factors had some influence.

Dr. DUVEL—Any further discussion?

Mr. REED—Several weeks ago I had an interesting experience with static electricity that may be of interest to those present. While at Winchester, Va., I met the president of the Virginia Woolen Mills and during my talk with this gentleman, I was informed that they experienced considerable difficulty in the carding of their wool. He stated that on certain dry or windy days, in a certain portion of the plant which was exposed to the wind, their carding machines would not operate properly, due to the fact that the static electricity which had accumulated on the carding machine would turn the wool and make it stand on end. The wool, in being carded, runs over a large cylinder and is taken up at certain points by another cylinder which has teeth on it, and in that way every strand is straightened out. Finally this wool is combed off the side of

the large cylinder and is run through two large rubber belts which slide back and forth and rub the wool together. The most difficulty they had with static was in running the wool between those two belts. There was an equal amount of friction between those two belts and the static, which would in some manner straighten out this wool and make it stand out on the side. As a result they would not get a perfect cord, or whatever it was they were trying to form (I am not familiar with the terms they use). I went into the plant and looked over the machinery. They were trying to keep the humidity in the plant as high as possible. In one section of the plant where they had carding machines installed above the dye room, from which there was a large quantity of steam coming up, they had experienced no such difficulty. That section of the plant is high and not exposed to the wind, but on the west exposure they experienced considerable difficulty. I recommended that a comb be placed on this belt and at the same time some sort of a comb be placed upon the rotating cylinders. There is considerable difficulty in the grounding of these cylinders due to the fact that the combs on the cylinder are imbedded in a cotton or woolen fabric. The combs on the cylinder do not touch the cylinder itself, which is made of steel, but each comb is separate, and is imbedded into this woolen fabric. Once a month they are compelled to grind these combs. One man told me that on one occasion he grounded a carding machine to a spool frame and said they had very good results.

Dr. DUVEL.—That is a very interesting observation.

Dr. BROWN—In our work in cotton we made an experiment whereby we pulled the cotton through a suction pipe and allowed it to strike against an insulated screen. We found a charge on the pipe and one on the screen and these were almost equal. When we gathered these together we had no charge. On actual determination we found an excess amount on the pipe over that on the screen, and we found that the equal amount of the positive sign on the charge was still on the cotton. In reality we might have had two different types of charges which were neutralized.

Dr. DUVEL.—If there is no further discussion of the two papers dealing with static electricity, we will take the report of Mr. Price on "Relation of Electrical Equipment to Dust Explosions."

"RELATION OF ELECTRICAL EQUIPMENT TO DUST EXPLOSIONS."

By D. J. PRICE.

Mr. Geo. H. Rice, who was to present this paper, as you know, went with the Hartford Fire Insurance Company the first of the month. I am not going to attempt to discuss the entire matter of electrical equipment in so far as it applies to mills and elevators, but want to present to you in a brief way what we have been doing with the electric lamp companies in connection with that phase of our electrical problem. You are somewhat familiar with the nature of that co-operation and have been informed from time to time of what has been done.

At the time of the Kansas City explosion last September our investigation was very difficult to conduct and definite evidence was lacking in many ways. One of the survivors, in fact the only one, said that he remembered noticing a blue flash, near the ceiling just before the explosion. It developed that the part of the basement where he had seen the flash was about the location of one of the electric lamps. This suggested the possibility that the lamp may have ignited the dust. We made renewed efforts to ascertain if this was the cause of the explosion. At the time the first poster was issued by the Department of Agriculture and the Food Administration, in view of the large number of cases brought to our attention where workmen had been lowering electric bulbs into dusty bins and explosions had occurred, we felt that a warning of some kind should be given to the men. We made five or six simple recommendations along precautionary lines and, as you recall, one of those measures suggested that the men refrain from lowering unprotected electric lamp bulbs into dusty atmospheres, or bins. That caused interest on the part of the lamp companies. Considerable correspondence was received in Washington from the Westinghouse Company.

They wanted to know what reason we had for making a recommendation of that kind. They referred to the work that had been done at Pennsylvania State College in connection with our attrition mill experiments and raised the question as to whether or not we actually had conducted experimental work showing that the use of these electric lamps was dangerous. We had not done so, but felt that in view of the cases in the field some warning should be given.

The Kansas City explosion led to direct relations being opened up between the Grain Corporation and the different lamp companies. We have had a number of very satisfactory conferences.

The three companies concerned are the National Lamp Works of Cleveland, the Westinghouse Company at Bloomfield, N. J., and the Edison Company at Harrison, N. J. In these conferences we have tried to work out definite lines of experimental work and further investigations.

The work handled divides itself into two simple classes: first, the possibility of explosions being produced by the breaking of the bulbs in dust, and, second, the possibility of fire or explosion from dust settling on the lamp. The first suggestion was almost cleared up immediately, as you know, in the work at Cleveland. In the tests conducted there, within a short time after the engineers began the work, they established very definitely that any type of lamp broken in a dust cloud will cause an explosion. We covered that phase of the work largely in our meeting in Cleveland in January. We have a number of cases in the field reported where explosions have been assigned to that particular cause. The experimental work settles beyond any doubt that the breaking of the lamp in the dusty atmosphere will cause an explosion. However, at the time of issuing the poster we thought that for some reason carbon lamps were more dangerous than the tungsten type, and even went so far as to suggest replacing all carbon lamps with tungstens, in some of the elevators, hoping that we were getting away from the danger. We found in the experimental work that the breaking of the tungsten was just as dangerous as the carbon type.

The second phase of the experimental work is giving us more concern. At a conference held in New York a few weeks ago it developed that difficulty had been experienced in determining whether or not ignition actually occurred by dust settling on the lamps. I understand from Mr. Dows and Mr. Hills that in the work at Cleveland the dust would smolder or smoke but they were not able to conduct any tests where the dust reached a point of incandescence or glowing heat. In the last conference the representatives of the lamp companies, after being furnished with a number of specific cases, as you recall—the cases sent in from the field—made a number of inquiries that had been suggested by the cases submitted, that related to fires being caused in that manner. To get the information in an authentic way we took up with you, by correspondence, the cases that you had reported. We sent the lamp companies, at their request, I think 17 or 18 cases of fires caused in that manner. Now, what we are trying to find out is whether in these cases that have been reported the men actually saw a glow or the dust reached incandescence or

whether it was just smoking. The engineers of the lamp companies are not doubting these facts, but desire to determine whether the dust was actually seen to be on fire. Now, to cite a case of what I have in mind, Mr. Court of New Orleans, as you will recall, at the Chicago conference, related the following experience (No. 4):

A workman, in a southern elevator, related an experience he had while using an electric light in a dusty atmosphere. He had been sent down into a small and narrow bin to do some cleaning. As he climbed down and brushed off the ladder which led down into the bin, he lowered the light into the opening ahead of him. During the cleaning-up process a great amount of the dust fell on the lamp and in a short time dimmed the light. The workman immediately climbed down to the suspended light and noticed that the dust on the globe was on fire. He did not know whether he should pick up this fire, put it into his pocket and run up the ladder, or try to extinguish the flames down in the pit. He climbed out of the bin and turned off the current to the light. As he states, every minute he expected to be blown to pieces, but he escaped because there was not enough dust in suspension to propagate the flames. *From that time on vapor-proof bulbs were placed on the extension lights in that elevator.*

Now, we recall very definitely, Mr. Court gave that experience almost word for word and so we took the matter up with him by correspondence and have a letter from him here. This was done after our last conference with the lamp companies. Mr. Court states:

“Received your letter this afternoon and in reply to my experience in elevator leg, when I was brushing down the ladders I had put the portable light half-way down the leg, and as I was going down, I was cleaning the steps and never noticed anything until I got to the light. As the globe was very dusty and I noticed it was smoking and very hot and, I believe, I saw small sparks, as I was in a hurry to get back up stairs. We had another experience at same elevator. The men were cleaning out the pit and were using a portable light without protector, and at noon time the men went to dinner and didn't put the light out, and when we got back from lunch we noticed a lot of smoke coming from the pit and we got a hose and put water on it. I believe it was only smoldering at the time as I didn't see a flame, but think there would have been a flame if it would have had a draught.”

There were three distinct cases reported from Minneapolis. Case No. 5. "The superintendent of a large Northwestern elevator relates that during the period that he has been engaged as superintendent of an elevator he can recall from twenty-five to thirty fires which originated from carbon lights. The dust coating on the globes became aflame and dropped to the floor, a small fire resulting."

We wanted to get the name of the elevator and the superintendent so that the information for the lamp companies could be accurate and complete. This case was reported by Mr. Lind of Minneapolis and was taken up with him with this result:

"During your recent visit here attending conference held in this office you will perhaps recall a discussion we had regarding experiences Mr. D. K. Whalen has had with carbon lights. Mr. D. K. Whalen is manager of the Exchange Elevator, St. Louis Park, a suburb of Minneapolis. It will be remembered that at a previous visit I had with Mr. Whalen the question of various electric lighting equipment was discussed with him, and at that time he related some experiences he has had with carbon lights. After relating these experiences, you advised that I again get in touch with Mr. Whalen, and particularly some of the men who have had like experiences, for the purpose of verifying or substantiating through these men the facts of the case.

Mr. Whalen advised that during his connection with the Exchange Elevator no less than twenty-five or thirty smoldering carbon globes have been observed in this plant. By this is meant that the dust would gather on the globe in layers, and because of the intense heat coming from a carbon light, said dust would begin to smolder, and very often this smoldering dust was seen to drop to the floor where it came in contact with dust there, but nothing of any serious nature happened to develop.

At a recent conference with Mr. Whalen and some of the help, it was brought out very clearly by these men that they had the same experiences in the past. This is merely to advise you, as you requested, of the correctness of Mr. Whalen's experiences."

I understand that Mr. Brady saw this superintendent further and that he also has information, if I am correct, that the workmen made the statement that they actually shoveled the fire out, so that the fire actually took place when this smoldering dust

reached the dust on the floor. Mr. Brady after talking with Mr. Whalen stated:

"Case No. 5 was witnessed by Mr. D. K. Whalen of the Exchange Elevator, Minneapolis. In a talk with Mr. Whalen on the telephone to confirm his experience will say that he claims to have actually seen the dust ignited and glowing. The dust coating on the globes became aflame, dropped to the floor and ignited dust down there. He claims there is no question about this, and that actual flame was seen."

When I was in Minneapolis we got in touch with Mr. Whalen and cleared up to my satisfaction that the dust was actually seen glowing by the superintendent and workmen.

The two other cases reported were witnessed by Mr. O. E. Lee, superintendent of the Interstate Elevator and Mr. R. W. Cote of the Cargill Elevator Company, where these fires were thought to have occurred, but as I remember they were not sure that they saw the flame.

Since we had our conference at Cleveland, Mr. Rice, who was to handle this matter, had an experience in St. Louis, in which he stated to me he understood that the dust was seen to be glowing—had reached the point of incandescence. The statement "glowing very brightly" was taken up by Mr. Rice directly with this company in St. Louis. That was a recent case in St. Louis, and there were a number of others, some on the Pacific Coast reported by Mr. Bodnar and some others in different parts of the country. I have referred to only a few cases in the 17 or 18 cases reported. In a number of them it seems almost certain that the dust was actually seen to glow or reach the incandescent point, while other cases were reported where the dust was only smoking or smoldering.

If the reports had been all alike, the work at Cleveland might seem to indicate difficulty in producing an explosion or fire from this cause. In the tests we have not been using light fluffy elevator dust, but mostly starch dust. Whether it was not the right kind of dust or conditions were not similar to operating conditions will have to be determined later by further experiment. It is a question that seems to be an important phase of the electrical work, because we have felt that possibly if the fire would drop through the proper proportion of dust and air an explosion would occur, but we have no information to indicate that such is the case. Fire probably would occur when that dust on fire reaches the floor. You will be interested, probably, in knowing

that in connection with the program sent to the lamp companies at their request sometime ago we outlined lines to be followed in experimental work. Twenty-four distinct lines were suggested by the men on the work. At the conference with the engineers of the lamp companies in New York recently it was decided that these lines of work should be divided, some to be taken up at Cleveland, O., some at Harrison, N. J., some at Bloomfield, N. J., and some in the electrical laboratories at Pennsylvania State College. On some of the lines that have been suggested, of course, the lamp companies have the information available, but there is still quite a little work to be done experimentally on the problem and we are hoping that even in view of the uncertainty as to what we can do after July 1, we can take care of this phase of the work. The lamp companies have been co-operating with us so splendidly that we hope to be able to make some provision for a continuation of the work.

When I was in Denver some time ago the manager of one of the large grain interests in the Northwest (I think he told me he had 175 plants) took up this question with me. He told me that they had ordered one Marine type fixture for every plant so that the superintendent could try it out and see how he liked it. I thought that was a very marked achievement, because the company took it up with us at Washington and merely on our suggestion immediately got in touch with electrical companies and secured this equipment. The trade is demanding and requesting information on this line. As we discussed at Cleveland, we say we cannot use lanterns, we cannot use open lights, we condemn gas jets, we are finding fault with electric lights, and we are unable to recommend a light that is safe. I am very happy to state that the engineers of the lamp companies feel now that it will be possible to overcome this difficulty. It may require a vapor-proof globe in all cases. In lack of further information we are recommending that vapor-proof globes should be used in all cases to get us away from these dangers that present themselves.

I have confined myself entirely to this work with the electric lamp companies because Mr. Fox from the Edison Lamp Works is here with us. Someone may have something additional to offer regarding cases which have been observed by you or brought to your attention where dust has reached the incandescent state and fire resulted.

Dr. DUVEL—We have this very interesting paper before us and as Mr. Price has said, in this work we have enjoyed the assistance and co-operation of the three big electric companies, the Edison, Westinghouse, and National lamp companies, and I want to say in this connection that I think that has been very helpful co-operation in every way. We have the pleasure of having with us this morning Mr. Fox of the Edison Company and I would like to have him open this discussion and present some of his own results and reports, in fact, I might suggest that he present these results, first, and the discussion can follow.

SPECIAL FEATURES IN LIGHTING.

By E. B. Fox, Commercial Engineer, Edison Lamp Co.

Mr. FOX—(First makes sketch on blackboard, Fig. 1.) We have had several letters requesting information about a mill

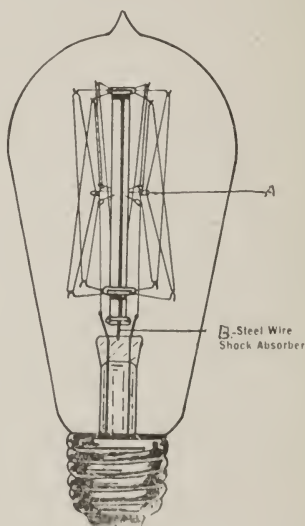


FIG. 1.
Mill type lamp.

type lamp and there seems to be possibly a little misunderstanding as to just what that lamp is. The mill type lamp some people think burns at a low temperature, but there is really very little difference in temperature between the mill type and the regular vacuum lamp. This mill type lamp was invented for places where you have a great deal of vibration. In an ordinary lamp when the filaments are burning they get soft and are apt to come

together, stick and lock, which cuts out part of the filament and the rest of it is burned at a much higher temperature, which cuts down the life. In the mill type, part of the filament is held by short anchors (Fig. 1-A) and that brings this part of the filament (indicating) out of the plane of the adjoining part and makes it impossible for the two to lock together, no matter how much vibration there may be. There is also a little steel connection in the form of a spring (Fig. 1-B), so that the stem is able to vibrate. This last simply makes the lamp stronger. The difference in temperature between the two lamps is not over five or ten degrees Centigrade.

The thing that got the lamp companies started on this dust explosion work was that the Millers' Mutual made a ruling that gas-filled lamps could not be used in flour mills. We found they had no particular information as to what the risk was supposed to be. They knew that the gas-filled lamps were hotter and for that reason considered it safer not to use them. So we started investigations. Our first experiments showed that we could get explosions by breaking any of the three kinds of lamps, gas filled, vacuum, or carbon—the only exceptions were in the case of the small sizes of carbon and vacuum lamps (below 30 watts)—no explosion occurred. So it doesn't look as if there is any question of ruling against any particular type of lamp. Now, in our present experiments we are using a hot plate. You have probably seen the ordinary hot plate that is used under chafing dishes, etc. This is connected up with a thermo-couple. We had trouble making the connections, which has held up the work somewhat. With this plate we found that we could not get incandescence below 500 degrees Centigrade. We have no lamps that show over 356 degrees Centigrade. So we have been trying to get all the information we could as to fires started by lamps and up to the present time haven't been able to get any in our experimental work, though because of the large number of instances reported it seems probable that we may succeed if the bulb is raised to a high temperature by some unusual condition.

Though not directly in line with this question, it might be a good thing to realize that mill owners are spending a great deal of money for very poor lighting. Take an ordinary vacuum lamp—your light goes out in this way (indicating Fig. 2 broken line curve).

Practically all horizontal at the sides. That is the way they are burning them, directing no light down here (indicating below the bulb). If they put on a shade of some kind, the

light is re-directed and you get it where you want it. (Fig. 2. Solid line curve. The dot-and-dash line shows bowl frosted lamp with shade.) It seems to me that this point should be taken up with them. They might be able to use smaller lamps and there would be less danger from broken bulbs. Vapor proof fixtures are made with a shade, so they are at no disadvantage from that standpoint. I noticed one particularly bad case in Weehawken, N. J. A man had hung a 100 watt light in front of the scale beam so that the light was between the scale and his eyes. If he was unable to see the scale I suppose he would hang a larger light in the same place. Mr. Reed spoke in his paper about having surfaces which would

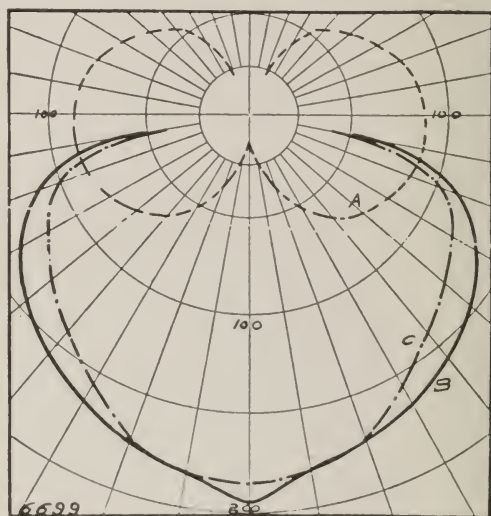


FIG. 2.
Showing distribution from bare lamp and with shade.

not collect the dust. That was one point I wanted to ask him about. We all know you cannot get any particular angle which won't collect some dust. Is there any particular angle to which you referred, Mr. Reed?

Mr. REED—Of course the angle of repose of dust will depend on the nature of the dust accumulated. I made that statement more or less as a means of preventing large dust accumulations from forming. For instance, in some points of an elevator as much as six inches of dust can accumulate, for example, on window ledges. If they were built up this way (indicating a sloping surface) instead of straight out, less dust could accumulate.

Mr. FOX—I supposed that was what you meant. Now only one other thing—I think probably most of you have seen the questions made up at the last meeting. I think we have asked an awful lot of questions. However, we hope we shall be able to get some of them answered.

Dr. BAILEY—Did I understand you to say that the hottest temperature, even at the surface of these globes, is 356 degrees Centigrade? Of course the temperature on the inside would be considerably higher?

Mr. FOX—The actual temperature of the glowing filament of the Mazda "B" lamp is about 2200 degrees, the Mazda "C" lamp about 2800 degrees and melting point of tungsten about 3400 degrees Centigrade.

Dr. BAILEY—I don't understand just what is meant by "B" type and "C" type.

Mr. FOX—The "B" lamp is our vacuum lamp. The "C" lamp is filled with nitrogen or argon.

Mr. PRICE—We understand, Mr. Fox, that in the hot plate tests the minimum temperature was 540 degrees?

Mr. FOX—Between 500 and 550.

Mr. PRICE—So we have a difference of 200 degrees.

Mr. BODNAR—About what was the color of the glowing plate?

Mr. FOX—I haven't seen the plate. Haven't been able to get out to Cleveland since they had it connected up. I am going out in about two weeks.

Mr. BODNAR—Did your firm also make temperature observations on the surface of the ordinary Mazda lamp bulb?

Mr. FOX—They made some tests with nitrogen filled bulbs.

Mr. DEDRICK—Would there be any objection to making the globe cylindrical in form and having on the top a non-conducting material, as asbestos, between the sockets, so that the dust falling on the top of the bulb would not be heated? That would do away with the angle of the globe.

Mr. FOX—I think possibly I can explain that. The Mazda "C" lamp is, of course, the hottest. The bulb is filled with an inert gas and in the neck of the bulb we have a

mica disk (A), which keeps the stem (B), as shown in figure 3, quite cool. The hottest point of your bulb is at C, figure 3. Our reason for putting in that disk is to keep the base and also the stem cool. We have to have a special glass for this stem, because we find that other glasses above certain temperatures become conductors and the glass is broken down around the leads and gradually you get a leak. If the bulb were cylindrical, the disc would not be as effective in keeping the hot gas away from the stem seal.

We make tubular lamps for moving picture machines. The blackening takes place in this lamp up above the filament as the lamps are burned tip up. Practically all the regular lamps are burned tip down and there would be no way of protecting the stem.

Mr. DEDRICK—I had reference to the settling of the dust on the top of the lamp.

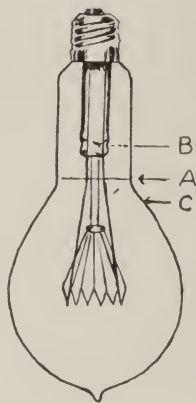


FIG. 3.
Mazda "C" type lamp.

Mr. FOX—You see all of these bulbs will be blown by machinery and I don't know whether we would be able to increase the angle.

Mr. BATES—I understand from the drawing (Fig. 2) that the radiant energy is given out in about that shape. Naturally heat would be given out in about the same way. Have you considered the idea of an inverted pear shaped globe where the chance for dust collection would be on the taper, and above that some form of energy disbursement so that the part where it went through the globe, instead of being an angle like this would be an angle like this and no chance for the dust to settle? It appears the dust would collect up here

and you could guard against that, possibly, by having an air space in there.

Mr. FOX—Well, that particular lamp is a vacuum lamp. Is that what you are referring to, or are you referring to a gas filled lamp? I am afraid that this bulb shaped like a strawberry, with the filament at the small end, would not be practical for manufacturing reasons.

Mr. BATES—Another thing occurred to me—that the increased temperature of the gas filled lamp is probably due to the fact that you get both the heat of radiation and conduction.

Mr. FOX—Yes.

Dr. BAILEY—356 degrees was measured on the surface of the bare bulb. Wouldn't that amount to more if the bulb were coated with dust? Wouldn't that dust coating hold in the heat?

Mr. FOX—Of course with a heavy coating the temperature rises.

Mr. REED—Can you tell me in general figures just what per cent of the present bulb would be covered with dust? I judge about 60 to 70 per cent.

Mr. FOX—Probably. Not much less.

Mr. REED—In other words the light will be decreased at the same time.

Mr. FOX—Yes, cut down 40 to 50 per cent in two or three weeks simply by dust collection. If we put a vapor proof fixture around the bulb there you have your straight walls and less chance for the dust to collect.

Dr. DUVEL—That would also protect the bulb from dust a great deal.

Mr. FOX—Yes.

Dr. DUVEL—The accumulation there would be slight and they would clean it off from time to time.

Mr. McCOLLAM—About what percentage decrease in illumination is caused by a vapor proof globe?

Mr. FOX—Hardly appreciable as the globes are of clear glass.

Mr. BODNAR—Do you think it would be necessary to have a vapor proof globe if you have a shade? I believe there is a natural rise of air through the top opening of the shade, so that no dust would settle when using a shade. Is that the case?

Mr. FOX—From a question of protecting the lamp from breakage you want all the protection you can get.

Mr. HELMKAMP—Don't you think it would be possible to equip this globe with some sort of shade and have the whole thing together?

Mr. FOX—They do make such a shade and globe. The only thing we want to be sure of is that all these precautions are necessary.

Mr. BRADY—Just why did the insurance companies rule against the nitrogen lamp?

Mr. FOX—They knew it was hotter and desired to be on the safe side. They had run no tests, but told us they would be glad to have us do so.

Mr. BROWN—How long was that dust accumulation allowed to remain on the bulb in making the tests?

Mr. FOX—Only one hour on the one I saw, as the test was made just before I was leaving and I didn't have time to wait any longer. In some cases it was allowed to remain on four and five hours.

Mr. BROWN—I was wondering what difference that would make. Of course in some of the plants it is allowed to accumulate for months and becomes baked on.

Mr. BODNAR—In one of the elevators that I visited I found a 75 watt Peerless Mazda in the dust on the floor. A little dust had collected on it and I added a little more. In less than two minutes it started to smoke and I don't think I had over $1/32$ of an inch of dust on it. It doesn't take very long.

Mr. FOX—We have no difficulty doing that at all, but we can't get the dust to burn. Another possibility in some of these cases where they think they have seen fire is that, when you get dust charred on the bulb you see the filament through it and it appears as if the dust were glowing.

Mr. PRICE—I wanted to ask Mr. Fox if there have been any further developments since our conference in New York about a month ago?

Mr. FOX—Mr. Dows, I believe, has gotten the machine running in which he is going to have the lamps surrounded by a dust cloud for a long time.

Mr. PRICE—For the information of our men I was wondering if you could tell us what plans the lamp companies have regarding future work.

Mr. FOX—Our present plans are to keep on experimenting until we can make definite suggestions to the fire underwriters.

Mr. DEDRICK—I will make a statement in regard to a lamp being lowered into a bin and lying for a while covered up. That happened in Chicago at one of the plants. It just happened at the time of my visit and while I was talking to the men. I had made a point in regard to the possibility of having fires and explosions from electric lamps. A man came toward us with a shovel which was a mass of coals with an electric lamp which was broken. (This was ground feed, oats, I believe.) It was on the point of flaming, that is, it was all live coal. It was found that one of the fellows had lowered a lamp into a bin to see how much was in the bin, then left the lamp there in about two feet of dust or material. Someone smelled smoke and found the lamp burning, pulled it up, and went down into the bin and discovered the mass of coals, which were shoveled out to remove all the fire. The superintendent was there and it emphasized the dangers of being negligent in using lights, putting them down into bins and leaving them. I don't think that lamp was down there more than half an hour or possibly three-quarters of an hour.

Mr. FOX—I don't think there is any doubt about that occurring. We have even had a case of a man who took a lamp and put it in the bed to keep his feet warm (it was a cold night in winter), and it burned up the bed. (Laughter.)

Mr. BATES—A circumstance just came to my mind, though not actually along the lighting question, of an incident that occurred in an elevator not a hundred miles from here, of the overloading of an electric circuit by connecting an electric moisture machine onto an ordinary lighting circuit. This was a four-compartment machine, each compartment requiring about 4.6 amperes of electricity at 100 volts. That would be equivalent to something like 75, 25-watt lamps, which, of course, is greatly overloading the circuit and endangering the elevator from fire due to the heat generated in the circuit. That is just one case

that we have seen, but as electrically heated moisture machines come into use more generally, it is something that we should look into very fully. The machines should be properly connected by wires of sufficient size to satisfy the underwriters' code for electric circuits.

Mr. HIBBARD—Don't you think a fuse plug there would take care of that, a fuse to melt at about 8 or 10 amperes?

Mr. BATES—A 10-ampere fuse would be of no use on a circuit where 20 amperes were required. Then some one would probably substitute a tenpenny wire nail for the fuse.

Dr. DUVEL—That's the difficulty. In those cases, heavy wire is often used. As there are more of these machines coming into use this is an interesting question. Is there further discussion of this matter? This question of electric lighting in elevators is undoubtedly a very important one. There have been some interesting developments in the last six months and we feel that in another six months' time something will come out of this. If there is no further discussion on this we will pass to the next paper.

Mr. Riley will give us some of his experiences in the presentation of dust explosion work before high school students.

“PRESENTATION OF DUST EXPLOSION WORK BEFORE HIGH SCHOOL STUDENTS.”

By MR. E. L. RILEY.

Mr. Chairman: In February, while in Springfield, Ohio, I visited the two high schools there and presented our work, and seeing how well it was received by both faculty and students, I decided to visit the high schools, wherever it was possible to do so, providing, of course, that it did not interfere with my other work in any way. In presenting this work I give a short talk on conditions necessary to produce a dust explosion and then go on to tell what the United States Grain Corporation, co-operating with the U. S. Department of Agriculture, is doing to eliminate these dangerous conditions in the mills and elevators of this country. After this brief talk I give the demonstrations, using various dusts, such as elevator dust, flour, corn starch, wood dust, spice dust (from spice mills) and pulverized sugar, and after giving the demonstrations I try to answer any questions that may be asked. In one school I visited I discovered an instructor who evidently had never had an opportunity to

read any of our literature pertaining to grain dust explosions and was still instructing his classes according to the old form of text books that teach dust explosions in mills and elevators are caused by spontaneous combustion. This instructor informed me that explosions in mills and elevators had been discussed in the class-room the week previous to my visit to the school and he had informed the students that they were due to spontaneous combustion. He advised me that he would be glad to use any literature that the Department had in his work in the school and he hoped to be able, on receiving this literature, to go more deeply into the subject of dust explosions. It may be well to mention here the fact that every principal and instructor I have met, while visiting the schools on this work, has stated his intention of following up this work and has asked for bulletins and publications on the subject, in order to prepare himself to give the information to his students. I have experienced no difficulty in arranging for the presentation of the work at the various schools visited, but always found the faculty only too glad to allow me the time I needed to give the talk and demonstrations. In some schools visited I have been ushered into one of the class-rooms by the principal, introduced to the instructor in charge and have then introduced myself and my work to the students, but in a few of the schools I have been received on a more elaborate scale, one school in Buffalo going so far as to have the school orchestra of eighteen or twenty pieces take their places on the stage with me and render a few selections, both before and after the talk and demonstration. I am sorry to say that I have not had that experience very often. The attendance at this one meeting numbered 1,500 students and my audience never ran under 80 students at any time. At another Buffalo school I visited, the students endeavored to show their appreciation of the work and my efforts in their behalf by having the cheer leader step onto the stage where he led the students in the school yell, ending with "Yea, Riley." As the attendance numbered from 800 to 1,000, it was some "Yea." Many questions were asked by the faculty and students in regard to dust explosions and their prevention, and I believe from the interest taken in this work, that the time given to it was not wasted, for in my opinion the best way to spread this work of dust explosion prevention is to bring it before the faculty and students in high schools, and if, for lack of funds men are not available to present it, films that we now have could be turned over to the State educational authorities and through them could be sent to the

various high schools in that State, giving special attention to schools in sections where the grain or milling interests are largely interested. I believe that by doing this the work will have a far-reaching effect, and before many years have passed we will have mills and elevators that will be explosion proof, or, in other words, free from dust.

Dr. DUVEL—This has brought out some very interesting experiences on our educational campaign that has been carried on. You will probably wonder why the Grain Corporation got off into this phase of dust explosion work. Of course, when we first started it was primarily to protect our own interests, but we felt that as we were co-operating with the Department of Agriculture we could not be severely criticised, and as Mr. Riley has stated some good will come out of it, even though the Department of Agriculture is not going to be in position to follow this work up.

Mr. PRICE—Special motion picture films of a popular nature are now in preparation by the Department. They will be available for general use and can be circulated among the schools and colleges. They have been prepared with a view to meeting the need suggested by Mr. Riley.

Dr. DUVEL—Is there any further discussion?

Dr. BROWN—It seems to me that the question of presentation work in High Schools better be carried just a little bit further and take it in the colleges. I might state that I recently had the privilege of addressing a college audience. The president introduced me and we put on our performance and I feel that it was worth while; it was well received. I feel that agricultural colleges at least would be very much interested in the discussion of this question and particularly as related to the field work and threshing end of it, and that the milling colleges, where they give milling courses, would be interested. It might also be taken up in other branches of college activity and be extended by the films which we are having prepared at the present time.

Dr. DUVEL—I agree fully with Dr. Brown. By getting this into agricultural colleges, you get in direct contact with those who intend following this line of work. I believe it would be a fine thing if the Department could prepare something very definite for a series of lectures for the agricultural colleges to go right into or to be made a part of their courses, and arrange to furnish them films or loan them films or slides, or something to demonstrate.

Dr. BAILEY—I think they should also go to a number of engineering departments. We are training a number of men in engineering aspects of cereal work and those men do not get much chemistry. Sometimes they go away—leave college with a bad misconception. Then we are increasing our technical department. They are sending men where these films would be very useful. They are keen for that sort of thing and we are looking for them all the time.

Dr. BROWN—I think that Dr. Bailey's idea might be extended not only to include those men who are getting into cereal work, but to all types of industrial work.

Dr. BAILEY—There are many men who will go into the cereal industry, and I think they should certainly be provided with this material. I think the men who are in college now should get this training.

Mr. RILEY—I think the engineering courses should give consideration to this work.

Dr. DUVEL—Is there any further discussion?

Mr. REED—I think the colleges should be visited before high schools. Mr. Riley says that by reaching the high schools you reach them all, but you reach them before it would be necessary. I doubt very much if they would hold a meeting at the high school I attended; such a man would be at a disadvantage.

Mr. RILEY—One of the meetings I held happened to be in his state and they were very glad to have me there. The superintendent of education informed me that if I could not get there, to send a request to Washington that such a demonstration be given and to use his name in this request.

Dr. DUVEL—There is no doubt but that people are getting more interested in his subject. We have about covered the discussion on this subject; it is now after twelve and, I believe, we had better adjourn until this afternoon. I am glad to announce that Mr. Barnes will attend our meeting this afternoon and give us his views of the importance of this work.

Adjourned until 1:30 p. m.

FRIDAY AFTERNOON SESSION

April 23, 1920.

DR. H. H. BROWN, Presiding.

RESULTS OF WORK IN VARIOUS DISTRICTS.

Dr. BROWN—The meeting will please come to order. This afternoon we expect to have a discussion of some of the results of our actual work in the field during the past year, and more particularly the results of our inspection work. As you know, the work of the Department, in co-operation with the Food Administration last year, was divided into five districts. On account of curtailing some of the activities and having cut down the force, in the present campaign the country was divided into three districts. We will now hear reports of the results of work in these different districts, first in the East, then in the Central North-west and then the Pacific Coast. We will have all these reports and then follow with the discussion covering the entire country, rather than taking the various districts. I take this opportunity to call upon Mr. H. R. Brown, who has charge of the Eastern District.

REVIEW OF WORK IN EASTERN DISTRICT

By H. R. BROWN.

Mr. BROWN—Mr. Chairman: I had prepared a regular paper on this subject showing statistics by grade and number, but as one man who came into the office said, there are "white lies, black lies, and statistics", I therefore tore that paper up and you will have to take my word. The plants visited in the east were mostly those carrying Grain Corporation stocks. I think our best results have been obtained by the use of our miniature elevator and the cheese-cloth demonstration. We hope to be able to give you a demonstration later in the afternoon. I think we have this elevator demonstration down pretty fine now and quite an improvement on our former demonstrations. I might also call your attention to the method of giving the cheese cloth demonstration,—another improvement which I discovered about two weeks ago. In large halls where we have held meetings with an attendance of about 1000 people, I noticed that they had some trouble in seeing just how the fire is started. I found that by putting a larger amount in the cheese cloth and tying it on the end of a pole and then shaking the pole over the flame, that this makes the demonstration much more effective. There are two

other points I want to bring out in taking up the results of this work, and that is, demonstrations given before fire departments and the high schools. Mr. Riley told you about the high school demonstrations, and I think that matter was thoroughly discussed. It is agreed that it would be a fine thing to bring this matter to the high school students and also to the engineering societies in the colleges or technical schools of the country. I think our men made special efforts in different cities to take up this matter with the various fire departments. In this way we have obtained the co-operation of these men in reporting fires in mills or elevators. On certain occasions we have been able to get to the scene of the fire right with the company, the Chief taking the men to the fire in his car and they were there to see what was going on. This happened to Mr. Riley and Mr. Helmkamp. They happened to be at the fire house when the alarm came in. In one case the Chief called up the man at the hotel and picked him up on the way. They have been taught that it is especially dangerous to turn a stream of water into a cloud of dust. They have also been taught that it is to their advantage to visit the plants frequently and endeavor to impress upon the employees the necessity of keeping the place clean, not only for their own protection but also in the case of the firemen who would be called upon to fight the fire. There is one special feature I want to call to your attention. Mr. Witmer is the hero in this case. One elevator down in Philadelphia we have been after them for three years to put in an improved lighting system. They have been using open gas jets in this plant, so the foreman said, for forty years at least. We have called this to the attention of the manager, the foreman, the superintendent, and even taken the matter to the railroad company and the owners of the elevator, and they said their plant had been operating for forty years and nothing ever happened. We had just about given up this case, when Mr. Witmer seemed to get on the right side of the management. I am now pleased to say that an improved lighting system has been installed in this plant, which is one of the results for improving plants in the eastern district. A small number of explosions have occurred in the east. Later on we are going to take up several minor explosions,—two plants in Buffalo, and the Cincinnati explosion. Mr. Riley will tell you of the explosion at the Spice Works in Cincinnati and at the H. O. plant in Buffalo. Mr. Helmkamp will give you a short account of the explosion in the Curtiss plant in Buffalo. Mr. Price, in his summary of the work for the entire country, will give you some figures and

statistics, I believe, on the results of inspection work, showing improvement in the condition.

Dr. BROWN—I am sure this is an interesting report. Before we go on with a discussion of it, I take pleasure in calling upon Mr. Brady to give us the result of his inspections of the central and northwestern district.

REVIEW OF WORK IN CENTRAL AND NORTH- WESTERN DISTRICTS

By P. E. BRADY.

Mr. BRADY—Mr. Chairman: Our work has been confined mostly to the Grain Corporation plants. We have a large area to cover and it was our object to visit these plants at least once a month and make inspections of them. In doing that we found we could devote but little time to outside work. However, we used to get ten days out of every month whereby we could go to the various outlying plants, and we invariably tried to put on a show for the benefit of the larger mills. We always carried our pictures with us and invariably found a place around the mill where we could give a demonstration and put on the pictures. We found that the millers were very grateful for this work, and believe that we did considerable good in educating the men along the dust explosion hazards. We recieved very good co-operation from the fire departments through that portion of the country also, and in Minneapolis the Chief now has the men make a regular inspection of the elevators in that city, due primarily to the work that we have started there. We had occasion to investigate two explosions in that territory,—one was the Kansas City explosion in the Murray Elevator, the other an aluminum goods manufacturing company plant at Manitowoc, Wisconsin. In connection with the small meetings which we have had at the various small outlying plants, there has also been put on in that district probably 15 or 20 large meetings in the larger cities, such as Chicago, Milwaukee and Minneapolis, where Dr. Brown or Mr. Price have made addresses. No doubt Mr. Price has the figures and knows the number of meetings held in that territory, and as for making the summary, Mr. Price can fix up the figures on that I believe. We have made around 855 inspections in that territory altogether since the Grain Corporation took over this work. That completes the report for the northwestern district.

Dr. BROWN—Before we go on to the next report, I believe it would be interesting, Mr. Brady, if you could tell us some

specific instances of improvement that has been brought about in your district as a result of the inspection work.

Mr. BRADY—Well, I will take Chicago, for instance. I just had a letter from Mr. Farrell, in charge of the inspection work there for the Grain Corporation, and in that letter he said that he was very pleased to note that of late the reports which have been coming in from us had been showing a marked improvement in that a good many houses that were formerly in the "B" class had been raised to "A." I might say that in general that covers the entire northwestern and central district. There is no question but that the houses in Minneapolis have been improved, and one of the insurance men was remarking to me along those lines, just the other day, that since we started the work up there the elevators had been gradually improved, and he felt that it was in a large measure due to the educational work that had been done in the district.

Dr. BROWN—Of course, we realize that the greatest amount of grain in this country is handled through the Middle West and works east, and some of us who are in the East sometimes forget that they have grain on the Pacific Coast, and that they have problems out there, so that it has been necessary to extend our work to that section as well as to others. Mr. McCollam, who has had charge of the work in that section, will now tell us something of the results obtained there.

REVIEW OF WORK IN PACIFIC DISTRICT.

By M. E. MCCOLLAM.

Mr. Chairman: In making this report, I just want to speak very briefly about four things: First, the inspection work; second, the very beneficial educational tour on which Dr. Brown was associated with us in our district; third, the co-operation which we have had throughout our whole district with the State Industrial Accident Commission; fourth, the interest which other manufacturers and industries have taken in our work. In regard to the inspection work, Mr. Bodner and myself did all of that, and I am sure that I can report an improvement in all of the plants on the Pacific Coast that needed improvement. Besides giving attention to the Grain Corporation stocks in storage, which, of course, always came first, we concentrated our attention on the mills and elevators which particularly needed cleaning and which needed improvement. I might cite two instances

particularly in which mills were improved. One of these instances was a mill in San Francisco which was improved from a "CC" mill to a "BB." The other was a mill in Seattle which was improved from a "CC" mill to a "BA," and I do not think, in this latter instance, there can be very much more desired in the way of improvement. I have no explosion to report—no disasters or explosions in the Pacific District. The only interesting experiences along those lines I covered in my talk this morning.

In regard to Dr. Brown's meetings in the Pacific District, I might say that the meetings were held at Spokane, Tacoma, Portland, Seattle, San Francisco, Los Angeles, Stockton and Salt Lake City. The one at Stockton was held at the Sperry Flour Company. A very large number of employees were present, and I think it did a lot of good. All of the meetings were very well attended with the exception of the one in Spokane, although that had a very representative audience present. The co-operation of the State Industrial Accident Commission has been very complete. Every State in my district has an Industrial Accident Commission or a Safety Department. In the State of California one of their engineers has been assigned to accompany me on inspections that I made throughout the State and this has been accomplished in a good many instances. He has an automobile which makes it very pleasant for me, and we often tour around and visit plants together. He confines himself mostly to plants that I want to visit. In Oregon the co-operation with the State Industrial Accident Commission there was started by a conference which we had in Portland with the State Labor Commissioner and the Chairman of the Safety Board. Mr. Bodnar and myself put on a demonstration for them and told them all we knew about dust explosions. They were very much interested and promised co-operation. Since then that has been carried out, and on numerous inspection visits made by Mr. Bodnar he has been accompanied by a Safety Inspector. In Washington that has been carried out also—Mr. Bodnar having been accompanied by the Safety Inspector. In Utah and Idaho, the Safety Departments there are in their infancy, but I was promised in Idaho that as soon as they got their Safety Department working they would be delighted to arrange a tour through the whole State, at their expense, visiting any of the plants that I designated which I think should receive attention, which I think was a very generous offer. In regard to the interest in our work in California, I might say that the industries there are very much in-

terested. Just before making this trip, I had an interview with Mr. McBride, of the California-Hawaiian Sugar Refineries, at Crockett, California, turning out 1,700 tons of refined sugar a day and 40 tons of powdered sugar. Mr. McBride said that he wished it might be possible to have a man stationed at the refinery for some months to study the dust collection problems that they have there, and also that it might be possible for the plant to stand some of the expense, if such was necessary. Just to give you an idea of the interest which has been taken in our work, the other day we had a request from the Seattle Manufacturers Association for a demonstration and lecture before that body. The request came in from the Secretary.

Dr. BROWN—I certainly think that good work has been done on the Pacific Coast. We are a long ways from it but even though our work now has to be discontinued I can readily see where somebody could tour all of Idaho at the expense of the State, and possibly spend a few pleasant months on the Pacific Coast in the sugar industry.

These three subjects are now before you gentlemen for discussion. You have all worked in one or more of the various districts, and while we are later to have a general discussion of your personal experiences in making inspections, in which I hope each one of you will take a hearty part, we would like to have some discussion regarding the results of the work in these particular districts.

Mr. PRICE—I want to ask the men in the different districts what, in their estimation or feeling, has been the effect upon the trade or industry? Have you been well received, or have you met with any opposition, and what has been the general feeling in the respective districts?

Mr. BROWN—I do not believe there is a single plant in the East where we have had any trouble in making the regular inspections once a month or every six weeks. Now and then we would get into a discussion with the men as to how clean a plant should be kept, but as far as there being any real opposition or objection to our work, there is absolutely none at all in the district. In fact, we are commended for the work and the management is willing to carry out every suggestion we make. If we call their attention to dust accumulations, they are generally removed even before we leave the house.

Dr. BROWN—I think Mr. Price had in mind not the ques-

tion of objection, but of the receptivity of the industry to the work.

Mr. PRICE—Yes. Do we get what we want done, or generally speaking, do you feel we have gotten anywhere?

Mr. BROWN—Yes, I think the management of the different plants has taken up this question a little more seriously possibly during the last six months or year than they did at first. I do not know that we are any more welcome now than we have always been. They always treat us very courteously—the elevator superintendent usually arranging to take us to the plants in cars. I might call your attention to the case in Baltimore, where the elevators carried Grain Corporation stocks, and on our visits there the superintendents asked for our advice on a number of questions and have carried out our suggestions.

Dr. BROWN—I think it might be interesting if we would know the condition of the worst elevator in this district and its present condition.

Mr. BROWN—The worst case was an elevator where they were using open gas flames in a dusty room. They now have installed the latest improvements. In another elevator on a number of visits we found lanterns being used in the plant. They have electric lights, but when they start unloading or loading cars, the first floor gets so dusty that they can't see the electric lights, and the man carries the lantern around to find his way. We have taken that question up and I do not believe there is a lantern used in that plant. So practically all our suggestions have been carried out to the letter.

Mr. BRADY—As a whole we have had very good co-operation from the men. In Minneapolis, the Chamber of Commerce men have their association there and meet once a month, that is, the managers of these large terminal elevators meet there once every month. At the start we sent out the reports to the Zone Agent, and then it appears that these managers got ratings of the various elevators which were posted up on the floor of the Exchange. They at once started to compare their ratings at this meeting and some of them were good and some were bad. That had a tendency to stimulate their interest in trying to have one elevator compare favorably with the other as far as good rating was concerned. We did not continue that practice, but there is no question but that it had its effect. Once they got that rating,

the manager made it a point to impress upon his superintendent to keep that plant in good shape. As far as keeping the plants clean and carrying out the suggestions we made along those lines, we have had very good co-operation. We have also had to contend with the lantern in Minneapolis to some extent, as you have had in the Eastern district. As a whole, most of the superintendents understand the hazard of using a lantern, and we have only two or three in that city who continue along this line. The milling journals and trade journals have given us good co-operation, by giving notices, whenever we desired them, relative to meetings, and they have written up the results of some of these larger meetings, such as Dr. Brown and Mr. Price have conducted.

Dr. BROWN—How about the receptions you have received, Mr. McCollam?

Mr. McCOLLAM—The receptions that I have received have been all that could be desired. On the Pacific Coast there are three large milling companies, and every one of them is progressive, and they all seemed determined to co-operate with me as much as possible, and I believe in the case of one of the companies especially, they carried out nearly every suggestion that I made, and I believe that is the right attitude; that is, it reflected on the other two companies as well. I might say that I made a good many personal friends in the milling and grain trade. That may be desirable in one way and it may be undesirable in another way. It made it rather hard to make rigid inspections. On the other hand, they always seemed glad to get my suggestions and really mean to carry them out. I might say with respect to one large mill which is thirty miles from San Francisco, and it takes a day to make the inspection, that is, making the trip and making the inspection, and getting back, I was always received warmly and treated to lunch every time I visited there.

Dr. BAILEY—I wish to note briefly my opinion on the situation in the Northwest. I think it is very difficult for the men who actually are in the work to size up the situation as well as some of those outside. My feeling has been, especially in the last few months, that this work is leaving a profound impression on the industry in the Northwest. A great deal has been accomplished in setting those people to thinking, and giving them definite, concrete suggestions to carry out in the future in either remodeling or rebuilding plants in that district.

Dr. BROWN—I am sure this statement is very gratifying, especially from one who was at one time associated with us, and since that time and before has been associated with the trade. He has been able to obtain a perspective that we probably could not get. I would like to ask the men in charge of the district to say in just one or two words whether they feel that the work has been better received in the past year than it was last year, or in the past few months; or what has been the receptivity of the trade; has it been increasing or decreasing?

Mr. BROWN—In our work, I will say “yes,” it has been improving during the last year. I think the fact that the work was taken up in co-operation with the Grain Corporation has to a certain extent given us a better introduction at the plants. Perhaps the management has a very healthy respect for the Grain Corporation, or perhaps the work has been brought to their attention more forcibly through articles in magazines, and they seem to be more familiar with the work now and are more anxious to obtain our opinion on the subject.

Mr. BRADY—I feel about the same as Mr. Brown along those lines. There is no question but what they are paying more attention to the dust hazard than they have before. That is simply due to the educational work that has been done along this line. As far as being received any better now than we have been in the past, we are getting about the same reception.

Mr. McCOLLAM—I think Mr. Brown has struck the keynote of the matter when he said the work was becoming very well known among the milling trade. It is really a necessity, and I think they have realized that now, and that is why we have been received in such a hearty manner by the trade.

Dr. BROWN—Is there any further discussion upon this side of our inspection work? If not, I think we will proceed to the general discussion of experiences.

GENERAL DISCUSSION OF EXPERIENCES IN MAKING INSPECTIONS.

Dr. BROWN—I am sure that all of us who have been in the field, who have been in contact with the trade, and particularly you men who have had an actual contact with the men who are working in the plants, must have some very interesting things to tell us of your experiences, of the results

of your particular work. I am sure we would be very glad to have a general discussion of this question from each and every one. Don't hesitate and wait one upon the other, but somebody start. If you don't I will call upon someone.

Mr. HELMKAMP—I might say that at the start of the work in Buffalo, N. Y., we started putting on demonstrations and visiting each elevator and in all my visits there we had very good meetings. However, when I got to the Central District this work had been very well covered by Professor Fitz and Professor Swanson in the states of Kansas and Oklahoma and even though most of these plants had had a demonstration put on, I found no trouble, except in possibly a half dozen instances where they did not desire any demonstration. So I think that alone shows that the work could be continued along these lines.

Mr. BODNAR—In connection with the small blower that we have been using for giving dust explosion demonstrations is an experience that occurred to me for the first time. I was giving a demonstration with corn starch. The glass tube had something like two inches of dust in it and the resulting explosion from this amount of dust was sufficient to make the windows and doors of the office in which the demonstration was being given rattle quite audibly. As nothing like this had ever occurred during a demonstration in my experience, to prove that no wind from the outside had caused the windows and doors to rattle, I immediately recharged the blower with a trifle more dust than on the previous occasion. This time there was no doubt about it. Even the small amount of dust I was using was sufficient to develop a pressure which had its effect on the windows and doors. The manager and the men around showed quite a bit of interest in the demonstration. The manager of the elevator declared that if I ever revisited their plant I would certainly find it cleaned up properly.

Mr. WITMER—I feel that the "baby" elevator and the cheese cloth demonstrations were a great assistance in our work. I find that after giving demonstrations to the men at the different plants they were more careful and took a greater interest in keeping their plants clean. In several instances which I recall, the workmen when not busy with their regular work would be found removing dust accumulations from within the building, although having no instructions to do so.

Mr. PRICE—I had hoped Mr. Witmer would tell us about the demonstration in which he assisted here in New York, using the “baby elevator.”

Mr. WITMER—That demonstration was in a church, possibly the accoustics may have had something to do with it. The report was very loud. The top went off very successfully and I believe everybody was surprised and dumb-founded when they beheld the flame shoot out of the elevator. We had quite a gathering—one hundred, possibly—and everyone seemed to be greatly interested.

Mr. ROETHE—My contact with the officials and employees of different mills and elevators has been limited to visits in connection with tests made along static studies and for that reason I have not had the chance to get around as much as most of the men, but I was particularly impressed during my two weeks of investigational work last summer by the attitude shown by the different managers and foremen, particularly at Seattle and Minneapolis. When we stated the nature of our visit the managers were very anxious to help us in every way possible. They were interested even to the extent of accompanying us from floor to floor to see what developed and were very anxious to receive any information which would enable them to eliminate static charges, and I would very much like to see a further study made over a succession of days during the winter, perhaps, in order that conclusive results could be obtained and this information be compiled and published in an approved form.

Mr. LIND—I can cite possibly two instances. I will refer now to a new terminal in Minneapolis, a three million bushel plant of recent construction. I happened to be there possibly two months ago, and I was furnished with a guard who showed me throughout the entire plant and who also called particular attention to the various improvements that they have installed with reference to handling the dust hazard. Prior to this last visit I had also had a talk with the superintendent at a meeting that took place in one of the large elevators, another plant close by, in which he said they were experiencing considerable difficulty in their tunnels with reference to dust accumulation. This tunnel was two blocks long and while they used a pick-up system on the return end, they were not able to eliminate the accumulation entirely and for that reason would like to have me accompany him through an inspection

tour of the tunnel, which I did. At this time the tunnel was in a very dusty condition and I suggested then a collecting system, hooded over the entire length of the conveyor belt at intervals of possibly 40 feet, and he then suggested that it may not meet with the approval of the various state weigh masters and the State Grain Weighers Commission, but they were willing to experiment further and they did so. After the installation had been completed I again went over the plant with this superintendent and they had these suction hoods installed about every 40 feet. The belt conveyor is 36 inches wide. It is a direct suction in a sense but indirect in another sense, as the hoods are possibly 6 inches or more away from the surface of the belt. Since the installation they now have no trouble whatever with dust accumulations and you can see the entire length of the tunnel from the elevator end to the mill end. There were several other recommendations that I advised, which have been made, among them the installation of vapor proof globes throughout the entire tunnel.

Dr. BROWN—I am sure that we greatly appreciate this report and I might state in that connection that we have always had excellent co-operation with the large companies in Minneapolis. To give you a little idea of their interest in the dust question I might relate an incident which occurred in Minneapolis in the Fall—when we had our meeting there in November. Mr. Fitzimons and I dropped around to the office of the largest flour company and we found there one of the officials of another large flour company. Among other things, we were discussing with him the dust question. He told me that they were considering an installation whereby they would precipitate the dust and keep it from coming out of their collectors by use of a spray, in other words, by means of washing the air. I raised the objection that they would waste that product. He said: "It is not a question of the loss and value of the dust. It is a question of preventing dangerous conditions."

Mr. REED—I think most of you men have had some interesting experiences, but I consider that I've had the most interesting experience of any of you. I don't think any of you have ever had two policemen knock on your door at 6 o'clock in the morning and hand you a subpoena. I don't think any of you have had the experience of reading what you did not say in the morning newspaper. I wish to relate several other very inter-

esting experiences that I have had. In one case down in West Virginia I interviewed the general manager of the largest mill in that section of the country. In my efforts to explain the work to him I received a cool reception. He told me that he knew all about dust explosions and that I had better go upstairs and talk to the miller. He objected to the men seeing a demonstration. In the interview with the miller I was given every and all consideration that could be given to me. After I had seen the miller I walked down stairs to get my elevator in shape and in walking through the mill floor I noticed this same general manager, with a cigarette in one hand, strolling through the building. In talking to me, with a cigarette in one hand, he said: "I read all your literature and I know everything about dust explosions." He knew all about dust explosions and yet there he was strolling through the mill with a lighted cigarette. There were two explosions in that plant and in one case the plant was destroyed by a fire from a dust explosion. The miller related two instances where explosions had originated in the rolls.

Another instance down in Virginia, I interviewed the head miller of a very large mill in that section. I told him I wanted some dust to blow up the small elevator. He said, "I don't know of any place unless we go down in the basement." We went down into the basement. The electric light bulb had burned out. "Would it be safe to strike a match?" he asked me, even after I had told him about the dangers of open flames in mills and elevators.

Mr. McCOLLAM—I am very much interested in that spray method of collecting dust. That is a method used in chicle refineries. They take that into solution and crystallize it out again. I had hoped you would say something about electromagnetic or electrostatic collection of dust.

Dr. BROWN—Well, I don't believe we want to discuss that particular question right now. I might bring that out possibly in the paper I may give in the morning. I will keep that in mind.

Mr. REED—You just made a statement that one concern considered the necessity of removing the dust more essential than the necessity of keeping the dust and selling it. In other words you laid more stress on the removal of the dust than on its value. I was inspecting a feed grinding plant in Pittsburgh last year, in which the manager stated he wanted all the dust he could get, for feed, as he paid good money for it.

Dr. BROWN—Another pleasant experience. We will pass this up at the present time and unless someone else has something to say on this subject will pass on to the next paper.

Mr. DEDRICK—I would like to relate a little experience on the effect that the big explosion at Cedar Rapids had in Chicago. Shortly after our work ended with the Government I received a telephone call from a large elevator concern asking me to come over. They wanted to have an interview in regard to making some suggestions. They were very much alarmed over the possibility of having a dust explosion at their new plant—feed plant—concrete—supposed to be one of the latest improved plants. So I went over and we had a little talk and they requested me to go over both elevator and feed plants and make certain suggestions to the superintendent and make a written report, with drawings, suggesting the different points where they might make improvements. Mr. Hibbard and I spent half a day or more going over the plant. Wherever there was dust made, as at the elevator heads, bottom of the boots, in basement, along the belt conveyors, certain rolls and feeders, faulty dust collector connections, etc., we made a drawing. They were having one difficulty with their bins which were made of steel and rather narrow. The material packed in the hopper outlet so that when they came to draw it out it would bank up in the hopper. They had to make holes at the junction of the spouts and hopper so that they could use a pole to poke and start the stuff. I suggested the plan of putting an agitator in the bins with arms extending out so that they could work it from below, so that this would start the stuff without having it come down with a rush and causing a great litter and clouds of dust. There were, I think, altogether, about 15 different points where they could make improvements, and I made drawings showing how these could be accomplished. When I submitted the report they assured me they were going to follow these out. I don't know whether they did or not, as I was never there again. I left the work shortly after that. Perhaps Mr. Hibbard would know.

Mr. HIBBARD—I was at the plant about three months ago and they were still "going to follow out those recommendations."

REVIEW OF EXPLOSIONS DURING PAST YEAR.

Dr. BROWN—We have next on the program a review of the various explosions which have occurred during the past year.

As there are several of these and our afternoon is somewhat crowded and we are planning to have a little talk from Mr. Barnes, from Dr. Alsberg and possibly from some other men regarding some other phases of the work, I feel that we should limit the papers and discussion on these subjects to not over ten minutes each and consequently I am going to call you at the end of five minutes. This will give you one minute to sum up and 4 minutes for discussion. The first paper will be by Mr. Reed on the Kansas City explosion. Before we have the discussion I will then call upon Mr. Helmkamp and we will have the general discussion of the two.

KANSAS CITY EXPLOSION

By MR. J. O. REED.

The Murray elevator at Kansas City, Mo., was destroyed by a dust explosion on September 13, 1919. Fourteen men were killed, ten injured, and the property loss was estimated at \$650,000. The plant was constructed entirely of concrete, tile, and steel, and the most modern type of machinery obtainable was used. The Murray elevator was a plant of one and one half million bushels capacity, and consisted of three units, the working house and the two units of storage tanks. The explosion, according to the result of the investigations that were conducted after the explosion occurred, originated in the basement. Now this basement was perfectly tight. The walls in the working floor were tight and for that reason the working floor walls and the floor of the working floor were blown out. The explosion propagated up through the manlift tower on the side of the elevator into the "Texas" and blew out the tile walls of the "Texas". I don't think there is an explosion which has ever occurred in a grain elevator in this country in which there was more force displayed. I doubt if the Cedar Rapids explosion displayed any more force. The story of the explosion will probably be of interest to some of you. The men in the plant were cleaning up and during the course of the cleaning-up process the explosion occurred. Of course the newspaper reports came out later on and made the statement that there was so much dust stirred up in the sweeping process of the plant that a spontaneous combustion of dust took place and an explosion naturally would result. I would like to give you just a few points in the recommendations that we made. The first inspection was made on the 5th of September, 1919. In this inspection the following notations were made regarding the

condition of the plant, for instance, the equipment was said to be good and the maintenance very poor. These are the direct statements which were made in the report: "Clean up this house and keep it clean. Employ sweepers. Install vapor proof globes and remove all carbon filaments." At the end of the report the statement was made: "This plant is dangerous and even though fire-proof, will explode if its present condition is permitted to exist." That statement was made on the fifth day of September. On the 12th of September another inspection was made and the statement was made in the report that the maintenance of the plant was still poor and that the first recommendations should be carried out. Now I would like to give you, or just state to you the condition of that plant the day before the explosion occurred—but I haven't time. The Coroner's record contains all the evidence if you are interested.

Dr. BROWN—Mr. Helmkamp will give us a little of the effect of the explosion on the inspection work in the vicinity of Kansas City.

THE EFFECT OF THE KANSAS CITY EXPLOSION ON INSPECTION WORK IN THE SOUTHWEST

By H. J. HELMKAMP.

It was not until one month after the explosion at the Murray elevator in Kansas City that I took up the inspection work in that vicinity. One of my first visits was to the officers and the management of the Murray Grain Elevator. My reception there was all that could be expected. All the recommendations which were offered by our force were gladly received and I am pleased to say that a great number of them are being carried out in reconstructing their plant.

During my inspections of plants in the Southwest for the first few months the subject of the Murray explosion was brought up a great many times. Of course when there was any misunderstanding at any time as to the cause I corrected them and explained the cause of the disaster to the best of my ability.

The terminal elevators in Omaha and Kansas City, with the possible exception of one or two, I found to be the cleanest that I have ever found in any one locality and I think that this is the one big improvement which can be said to result from the Kansas City explosion. In nearly all cases recommendations were very gladly received and in many cases I was asked to pay particular attention to certain parts of the plant or to certain equipment in

the plant in order to determine the dust explosion hazard. At all times every possible courtesy was shown to the men engaged in this work.

Another improvement resulting directly from the Murray explosion was hiring of regular sweepers by all the plants that had heretofore had none, while those having sweepers put on additional men in order to keep the plant in as good a condition as possible. .

The explosion brought forth renewed activity on the part of the fire underwriters and insurance men. These men, who in the past had regarded a fire-proof plant as an extremely safe hazard, now began to hustle about and reinspect the plant with the dust explosion hazard in view. Several times during my inspections I encountered these men and together we inspected the plant and discussed the various hazards. So as another result, I might say that the Kansas City explosion brought home forcibly to the insurance and fire underwriters the dangers of dust explosions, and the fact that a fire-proof plant was not explosion-proof.

In summary I will say that the effect of the explosion on inspection work in the Southwest was not only to make the inspection work easier because of the fact that the superintendent made it a point not to hide any of the dangerous places, but would point them out and inquire for the remedy; but also the fact that recommendations were gladly received, although in some instances they were not followed out as promptly as you would judge. However, in many cases the plants which had been rated as in C condition by Mr. Reed were found to be in A condition upon my next inspection.

Dr. BROWN—Mr. Helmkamp has not used all of his time. Mr. Reed may utilize the one and one-half minutes remaining to tell us about the condition of that plant.

Mr. REED—The elevator was found to be in a bad condition. Only the floors had been swept up, where there was an indication of sweeping. Everywhere there were dust accumulations overhead and no effort had been made to remove these accumulations. At places there was so much dust on the flange of the "I" beams that no more dust could accumulate there, because the angle of repose had been reached. Every here and there were piles of dust. In the basement there was very much dust, especially overhead and on the trunking of the dust collecting system used for collecting the sweepings. This dust on the trunking of the dust collecting system was very black, old, fine

and dry. I gathered this dust, with the help of one of the Grain Corporation men, in a portion of a burlap sack and secured all I desired within about one lineal foot on the pipe. There was an excessive amount of dust in the shaft containing the stairways, elevator lift, and main rope drive. There were piles of dust and growing grain in the tunnels leading underneath the storage tanks. The dust was several inches thick on and underneath two grain cleaning machines located in the northern end of the working floor. The switch and fuse boxes were still very dusty. There was an excessive amount of dust and oil on the journals. There was a hot bearing on the countershaft driving the fan on the top floor with a great amount of oil on the journal. Oil, it appeared, had run through the top floor from the blower fan, and a large pan had been placed underneath this floor to catch the oil. On the top floor I found a very poor extension cord worn at the socket. There were many carbon filaments used for lighting everywhere in the plant. There was no protection on electric light bulbs and almost all these bulbs were very, very dusty. No vapor proof bulbs were used in the plant. I tried to inspect several elevator boots, but was unable to pull the slide out from underneath the revolving buckets, so I do not know whether these boots were clean or not. The trunkings of the dust collecting system were in a very bad condition and needed repair. On the top floor there was a partially filled fire extinguisher. Replacements, such as belting, elevator buckets, ropes, sacking, etc., were piled everywhere on the working floor and were covered with dust. The superintendent stated that the fan on the dust collecting system had broken down before my first visit and that it was for this reason that the plant was dirty, but I observed on both my visits that the fan was in operation. There was a great accumulation of dust under a large machine in the basement. Workmen had swept around but not underneath this machine. The general condition of the elevator, as compared with other modern elevators of the same type that operate at full capacity daily, was dirty and dusty. Without doubt the Murray Elevator was the poorest kept and dirtiest elevator in Kansas City.

Dr. BROWN—Now you have the report of this explosion and its effects on the plants in that vicinity before you.

Dr. BAILEY—I note from the photographs that apparently the grain drier was completely demolished. Was that especially dirty?

Mr. REED—That was demolished, I think, due to the fact that the walls in the working house were blown out.

Dr. BAILEY—Well, you don't think then, that it was the result of an explosion within the drier?

Mr. REED—No sir.

Dr. BAILEY—Grain driers usually are especially hazardous since the dust there is thick and dry.

Mr. RILEY—If the explosion had taken place in the drier the elevator wall would have been blown in, would it not?

Dr. BAILEY—I was not assuming that the explosion originated in the drier, but that it might have propagated through the drier.

Mr. PRICE—The tremendous force exerted by the explosion is indicated by the fact that parts of the 16-inch concrete wall were found a considerable distance from the elevator, so any equipment or mechanical devices were subject to a great deal of force by something falling as the explosion occurred.

Mr. REED—The entire working shed of the plant was blown away. There was nothing left of it. I wish I had better photographs here. I would like to show you just how the drier house was blown out. There is no indication that the explosion occurred in it, as part of the drier house would then probably have been on the working floor.

Dr. BROWN—You mean that the indication would be that it propagated from the working house through the drier?

Mr. PRICE—I would like to suggest, in connection with this explosion at Kansas City, that the superintendent was in charge 15 years as I recall it, and never had any previous experiences of this nature and was recognized as being very competent. I have had the question asked a number of times: "What reason can you give why this explosion did not occur before?" Now I know how we feel about that, but that to me is one of the peculiar things about these dust explosions, and why it would occur in the Murray Elevator in Kansas City and not in any others.

Dr. BROWN—I might state that here is a copy of Mr. Reed's inspection report. The first inspection was on the fifth of September. It states: "This plant is dangerous and even though fireproof will explode if the present condition is permitted to

exist." This statement was made on the fifth and repeated on the twelfth.

Mr. REED—Saturday afternoon at one o'clock I wrote a letter to Mr. Fitzimons and described to him certain things I had noticed regarding the condition of that plant. I don't think I had more than mailed the letter before the explosion occurred.

Dr. BROWN—We appreciate having Mr. Barnes with us and I am going to ask if Mr. Price will express to Mr. Barnes for us our appreciation of his activity in this work and then call on Mr. Barnes for a few remarks.

Mr. PRICE—Early in 1917, shortly after we entered the war, Dr. Alsberg of our Bureau felt that we might be in a position to assist the Food Administration in some manner since our men were familiar to a large degree with the dust explosion hazard. He suggested at that time that we might get in touch with Dr. Raymond Pearl, who was connected with the Food Administration. About that time the explosion occurred in the Dow Stores elevator in New York City. As you know, it was estimated that the grain destroyed was sufficient to provide bread rations for an army of 200,000 soldiers for an entire year. Dr. Alsberg thought that we should do something in the way of an emergency campaign. We again took the matter up with Dr. Pearl and he told us that we should by all means see Mr. Barnes and Mr. Bell. We arranged a conference with both of these gentlemen and they received us very kindly. Mr. Barnes was then arranging a meeting of the zone agents in New York and requested that we tell them about our work. That started the cooperation. It allowed us to work with the Grain Corporation. Our pledge cards were issued that you have been using and also a number of copies of the circular and poster in our emergency campaign. This continued up to the first of July, 1919, at which time the emergency appropriation was discontinued. At that time the Grain Corporation sent Dr. Duval to the Chicago conference and through his interest we arranged with Mr. Barnes for the Grain Corporation to continue this work. I know we all feel and appreciate what Mr. Barnes has done for us, because the cooperation has been most pleasant and the work well received. We are more than glad to have him with us today and I take pleasure in presenting Mr. Barnes. (Applause.)

STATEMENT BY MR. JULIUS H. BARNES, PRESIDENT,
U. S. GRAIN CORPORATION.

I have a great respect for the trained mind. I conceive that the most useful purpose that a mere business man can serve is to make effective the suggestions of trained observation. Rarely has a man been engaged in a work in which the direct result is so apparent as it is in this work. Wherever the tale of the showing of the grain dust explosion prevention work from August, 1917, to May, 1919, is told it makes a marvelous impression that carries conviction. If we take any credit for cooperation and association in it, it is because we had vision enough to see its importance. We get a complete and lasting satisfaction out of the results of it. I have a picture of you men as faithfully interpreting the details that to the average man would appear unimportant—I have a picture of you as faithfully interested that the proper precautions might be taken and the result comes before us in the splendid results achieved. I am really approaching the close of this service and your work under our encouragement with considerable regret. I regret it because I am afraid that in our commercial structure the vision will not be broad enough to carry it on in the way in which it should be carried on. I look to the intelligence and foresight of the big business organizations rather than yet to a real appreciation on the part of the Government, which represents the general public, to see the picture as we see it. I believe that you have made a record that you should be proud of. I desire to thank you for the spirit with which the work has been carried on and the efficiency with which it has been done. (Applause.)

Mr. PRICE—We are also pleased to have with us at this conference the Chief of the Bureau of Chemistry from Washington, who has been directing the work there while the Grain Corporation has been handling the work here. We shall be pleased to hear from Dr. Alsberg.

STATEMENT BY DR. C. L. ALSBERG, CHIEF, BUREAU
OF CHEMISTRY, U. S. DEPT. OF AGRICULTURE

Every man, of course, who amounts to anything at all, has some very personal ideals of service. My own personal ideal of service so far as the Bureau of Chemistry is concerned is that the service which the Bureau of Chemistry should render to the people of the United States is that it should be the technological bureau of the Department of Agriculture—that bureau which

carries on constructive work and constructive investigations that have to do with the industries that use as their raw materials the products of agriculture. Of course, of these industries the main one is the food industry. We, in the Department of Agriculture, are all apt to think that the object of agriculture is merely to furnish the farmer wealth. The object, however, is primarily to feed the people and secondarily to furnish the farmer with the best possible living. Now, in the Department, we have been thinking too much and too entirely of production and not enough about the industries that use agricultural products as their raw materials. It is one thing to increase production. It is another and equally important thing to utilize what has been produced to the best advantage. That is where my plans, my hopes for the Bureau of Chemistry come in—that it may be developed and may develop into the technological bureau of the Department of Agriculture, which will concern itself, as I have just said, with the development of constructive work, research if you will, development work if you will, involving the application of scientific research to the industries that draw their raw materials from agriculture, of which the food industry is, of course, the most important. Since that is my hope for the Bureau of Chemistry, it was a very great comfort to me that the Grain Corporation and Mr. Barnes in particular exhibited the very fine attitude that, when it was not possible for the Bureau of Chemistry any longer to carry on the grain dust work, the Grain Corporation was willing to take it over and carry it through for another year. I cannot say, Mr. Barnes, how much I personally appreciate your vision and your expression of confidence in the staff of men that had been gathered together when you were willing to undertake the further conduct of the work. I can also say at the present moment that the disintegration of the organization which has been built up, the cessation of the greater part of the work, comes to me as a real and personal blow, because, I believe, it has set back the Bureau of Chemistry a great many years in the fulfillment of that development which we have marked out for ourselves and which we hope to attain. This particular piece of work is, I think, perhaps I should say undoubtedly, the most splendidly successful piece of work along the lines of cooperation with the industries, along lines of developing constructive work with the industries, that the Bureau of Chemistry has ever undertaken. There have been many other pieces of work during the last five or six years and there are a good many pieces of work going on at the present time along lines of cooperation with the industries,

of improving conditions in the industries, of applying results of research work to the methods of improving production and service, but there is not one, even of those which have been successful, which is of the importance of this particular piece of work. Therefore, I say the breaking up of this piece of work sets back the work I have marked out for the Bureau a great many years. However, we are not going to give the work up entirely. We always have a little money that we can squeeze out here or there, but about the best that we can hope during the next year is to keep the work alive and do some of the fundamental research that has to be done in connection with it, so that if we are ever able to take it up again we will not have marked time.

All I can say in conclusion is that I personally (and I know I can also speak for the Secretary of Agriculture) fully appreciate and value the work which you gentlemen have done, the work which the Grain Corporation has done, that I personally want to thank each one of you for the loyal work that was done first when you were members of the Bureau of Chemistry and later when you were members of the Grain Corporation. I wish also, Mr. Barnes, to thank the Grain Corporation for enabling us to at least carry on the work a year longer than would otherwise have been possible. (Applause).

Mr. PRICE—I understand Mr. Barnes has never seen our elevator blow up.

Dr. ALSBERG—(preparing to leave). If there is any way in which the Bureau or I personally (that is all you who are not going to stay with us) can help you now or in the future why just say so.

PORT COLBORNE EXPLOSION.

DR. H. H. BROWN.

One Sunday afternoon down in Washington, my attention was called to a little clipping in a newspaper about an explosion in Port Colborne, Ontario, where a number of men were killed, extensive property damaged, etc. I tried to get a little further information from the press and then decided that somebody should go up there. I left that evening and was on the ground the next morning. I found the plant had been almost totally destroyed. I might state that it was a very interesting investigation because there were so many different leads which would indicate different possible causes. The first that was considered by most men was that a motor had started the explosion due

to hot bearings. This was because of the fact that there was dust accumulated on it and there had been a little fire around it before luncheon. But that idea had to be discarded when we considered that the plant was not in operation at the time of the explosion. Inasmuch as the plant had closed down there could have been no dust in suspension at that point. When we went down into the basement, we found a conveyor belt, running from one of the boots, badly burned and a number of men were sure that that was the cause of the explosion. Then right close to it there was another conveyor belt badly choked, grain thrown out over the floor, and that looked sort of bad, but they thought that that might easily have happened when the belt dropped, as both of these belts had dropped. We went up to the next floor and we found on the floor beside this one that had dropped a pile of grain and the buckets which had dropped down there. That might have happened after the explosion. We started along upstairs and found that all of the elevator legs had been blown out, some worse than others. The bin floor was covered over and a number of the walls had been blown out. After sifting all the evidence available and taking the opinions of a number of different men and trying to deduct the facts from the opinions and from the evidence, I might state that contrary to the opinions of the majority of the men with whom I talked the circumstantial evidence was so conclusive that I could not agree with the majority of them because of the fact, for instance, that the pile of grain which was in front of the loftier leg which had opened and where the buckets were hanging down—that that grain was covered with material from above. If that belt had burned in two and dropped as a result of the explosion this material would have been covered with the grain. This indicated definitely that that belt dropped and the grain was on the floor before the explosion. There was no question, after a little further investigation, but that a choke had occurred in an elevator leg at ten minutes to twelve. The men left the plant shortly after and on their return at noon smelled the odor of burning rubber which they thought was due to a hot belt in the basement—a belt which had become hot and was rubbing to one side. The evidence led conclusively to the fact that there had been a choke. We finally found a man who had been to the top floor of the elevator and only about two minutes before the explosion saw smoke coming out of the elevator and saw the flames of the burning belt, and only had time to get to the first floor before the explosion.

There are two interesting facts that I want to bring out. The side-wall construction of the bins, trough-plate construction, so-called, so as to support everything perpendicularly instead of getting the side pressure, allowed for a heavy accumulation of dust. A distance from the top of the bin to the bin floor of about six feet allowed the explosion to pass through into the other bins, blow through the bin floor and the roof above. One reason I believe that the explosion propagated through the bins or got into the bins in the first place, is that there was an opening eight inches wide by the width of the elevator belt, about thirty-two inches.

Another interesting fact which you may see from one or two of these pictures showing the lower portion of the plant is that there was not an explosion in the basement—no great pressure developed in the basement. There was suction there. All of the windows were drawn in. Broken glass was strewn over the floor showing that the explosion went upwards over toward the working side of the house. The windows in the basement were drawn in. You can see from this how the explosion might easily have propagated from the well and throughout the bins.

Dr. BROWN—Is there any discussion in regard to this explosion?

Mr. RILEY—Was the condition shown in that picture due to fire?

Dr. BROWN—That was due to the burning of the belt. Of course it burned entirely in two. When some of the men first entered the plant following the explosion (there was no general fire, the men entered the plant less than a half hour later) that particular leg was red from fire and was the only one of the 14 in which there was fire appearing at that time, although fire later developed in one of the others.

Mr. BATES—The only burnable thing in there was the belts and grain.

Dr. BAILEY—Was this elevator operated in connection with one of the mills or in connection with a railroad?

Dr. BROWN—No, it was not. It had railroad facilities but was operated by the Government. It principally was a house designed to take in grain from boats. Grain was transferred through the house to barges to pass through the Well- and Canal.

Mr. BATES—What is this wrecked barge which shows in one of the pictures?

Dr. BROWN—I might state that there were 10 men killed by this explosion—4 within the plant and 6 on a barge which was loading at that time alongside the plant. I said the house was not in operation. There was a little grain running from the hoppers into the spout—just finishing up the loading of the barge. The barge was sunk and the men killed by falling debris.

Mr. LIND—In taking up the reconstruction of this plant, have they given any attention to means of eliminating this hazard?

Dr. BROWN—It is my understanding that they are going to put in single leg elevators from top to bottom, enclosing the leg, getting rid of that well with its inherent hazard due particularly to the trough plate construction and the allowing of so much dust to accumulate; also put the bin floor down onto the top of the bins. In reality what they are planning to do is to extend the bins with smooth steel plates to the point where the original bin floor was. This will make the bins of tight construction and then vents will be placed around, which will be open to the outside air. They had a dust collecting system but it was not in operation on account of the activity of the Canadian Grain Commission.

Mr. LIND—Prohibiting its use?

Dr. BROWN—Prohibiting its use before the grain was weighed.

Mr. BATES—Was the elevator a total wreck?

Dr. BROWN—The bins were practically intact. The bins were not hurt materially by the explosion in most cases. The explosion seemed to be largely above the walls in the bins and of course went upward, venting itself at the top. The little building shown in the picture is the office building, which was demolished by the force of material blown there.

Mr. BATES—Was the grain in the bins burned?

Dr. BROWN—Only slightly on top. The loss was only about five thousand bushels out of 450,000.

Dr. BAILEY—Was the elevator destroyed in such a manner that the grain in the bins could be removed?

Dr. BROWN—Not by normal processes. It was removed by reversing the belts and allowing the grain to drop down and run up into the cars. If there is no more discussion we will take up the Denver explosion.

DENVER, COLORADO—EXPLOSION

By D. J. PRICE.

The explosion occurred on January 22, 1920, and was reported to the Bureau by the Denver Station of the Bureau of Chemistry. We requested the men at the Denver Laboratory to investigate and ascertain whether or not there had actually been an explosion. Mr. Helmkamp, of our own force, was the nearest man to Denver, but on account of his illness we were not able to get anybody out there. The men at the Denver Laboratory were handicapped as they had never previously investigated an explosion. All that they could do was to take the statements of the men that had been in the plant at the time and incorporate the same into a report.

This is the first flour mill explosion we have had to investigate since the explosion in Nebraska in September, 1919. The Nebraska explosion was due to a man striking a match. The information received at Washington indicated that the explosion at Denver started in connection with the dust collecting system. We had not previously investigated an explosion starting in the dust collecting system. This case was associated directly with the collecting of the dust. The dust collecting equipment was drawing the dust from the rolls and exhausting into a dust collector of the Prinz and Rau stocking type. I am going to read to you that part of the report as sent to us by the inspectors that made the investigation and also take from insurance adjusters' report that part referring to the fan as the cause:

"The fire above referred to occurred in the Longmont Farmers Milling and Elevator Co., at 2100 20th St., Denver, Colorado, on January 20, at about 4:15 p.m. The building in which the fire occurred is a four-story brick, with basement. The rolls are on the second floor and as the grain passes through these rolls a current of air is drawn through and over the grain, known as roll exhaust. The air from all the rolls, twenty-two, is all drawn to a common trunking, and passes through the controlling fan, which is just above the third floor. From the fan the air is blown through an elbow of trunking, of about 6

or 8 feet, to the dust collector where the damage occurred.

These trunkings or pipes coming from the rolls are all galvanized iron and increase in size as they advance from the rolls to the fan. This is necessary as the main trunking is constantly receiving additions from the various rolls. The pipe from the fan to the collector was about 12 inches in diameter.

The fan, which was operated from a line shaft overhead, was of paddle-wheel type and was made of steel enclosed in steel casing. This casing was a part of the fan and revolved with it. The entire fan operated inside the galvanized iron fan chamber. This fan was held on the shaft with a key held in place with a set screw. An examination of this fan disclosed the following conditions: The play between the fan casing and the fan chamber on the right side was about 1 inch, while the play between the fan casing and the fan chamber on the left side was nil. At the same time the overhanging end of the fan shaft extended about one-half inch and was bright and polished. This would seem to indicate that the fan had slipped to one side about a half inch, and in so doing the fan casing came in contact with the sides of the fan chamber causing friction which in turn caused a spark which ignited the dust being handled by the fan.

The dust coming from the rolls contained not only dust from the outside of the wheat, but also an appreciable amount of flour, (an estimate of the amount could not be secured) though the current is kept low to prevent too much loss in flour through this source.

A Mr. H. Evers, employed in sweeping the floor at the time of the accident, described the occurrence as follows:

"I was working with my back to the fan when suddenly there was a big noise. I turned around at once and it looked like the whole end of the building was nothing but fire and smoke."

In answer to my inquiry as to whether he noticed whether or not the explosion damaged the dust collector, he replied that he did not look as the only thing he was interested in at that exact moment was self preservation. As the trunking leading from the fan to the collector was found on the floor after the fire, it appears that this part was blown off. It further appears that this was the only

damage done by the explosion itself. The fire spread instantaneously to all parts of that floor and the one above. The fire alarm was turned in at once and fire extinguishers were used until the arrival of the city fire department.

Following are more direct answers to the questions submitted in your letter to the Station, January 29, 1920:

The dust collector was of the "stocking" type known as the Perfection Dust Collector and manufactured by Prinz & Rau, having been installed as part of the original equipment, and exhausted inside the mill proper. It received the dust from the rolls.

The trunking from the fan to the dust collector was about 8 feet in length and 12 inches in diameter. It formed an elbow from the fan to the dust collector.

As to the type of fan used, everything was of steel or iron.

The product being collected consisted of dust from the rolls.

The fan bearings had never caused any trouble. To use the words of the miller, "the fan always worked like a charm."

Trunking was made of galvanized iron. Employees, while familiar with static electricity, had never noticed any in connection with this collecting system. The explosion itself was not so violent as it appears that the only damage done was to blow off the trunking leading from the fan to the dust collector. No unusual sound had been noticed by anyone prior to the explosion.

As for devices to prevent dust explosion, the miller, Mr. Thompson, stated that so far as he knew no devices had ever been installed for the purpose of preventing dust explosions. (Mr. Thompson has worked at this mill since it was built.)

Employees were familiar with the possibility of dust explosions as Government agents had visited the plant about a year ago and lectured on the subject.

The mill was in full operation and the dust collection equipment was working normally.

The mill is lighted by electricity and while a fire from this source is always possible, it is not likely that this one was due to this cause, as the lighting wires and fixtures were frequently inspected. All blue prints, drawings, etc., of the flow or dust collecting system were destroyed by

the fire and the miller said he could not draw one from memory.

No settling chambers were used in connection with the dust collector. The collector seemed to be large enough to accomplish its purpose as it had been operating successfully since installed (about 1907).

Loss of life, none; loss to building, about \$23,000; loss to machinery, \$56,000; loss to stock, \$30,000.

The explosion occurred in the fan and extended through a trunking of about eight or ten feet, which was blown off, to the dust collector and then to all parts of the third and fourth floors. In short, the dust in the fan was ignited which in turn ignited dust in all parts of these floors, the fire spreading so rapidly that it amounted almost to one explosion over these floors. This was the first fire that ever occurred in this mill.

The weather on January 20, 1920, as reported by the United States Weather Bureau, at Denver, was as follows:

Temperature, 25 degrees F. from 10 A. M. to 6 P. M.; cloudy; trace of precipitation in morning between 2 and 4 A. M.; wind from N. E., and blowing eight miles per hour at 4 P. M. The average relative humidity for the first twenty days of January was 60 per cent. The relative humidity for January 18, 19 and 20 was as follows:

	6 A. M.	6 P. M.
January 18	25%	14%
January 19	14%	28%
January 20	82%	74%

The mill was steam heated. No ventilation was provided except through the windows and these, according to Mr. Thompson, the plant miller, were very likely to have been closed that day as the relative humidity was comparatively high and the temperature low.

All employees were considered entirely trustworthy. No incendiarism or malicious intentions are suspected."

From report of insurance adjusters:

"The fire occurred January 20, about 4:15 P. M. and started on the third floor northeast corner of mill proper where a Reliance steel plate exhaust fan No. 45, 16 x 16 was working on roll exhaust and discharging into a Perfection cloth dust collector. The fan blades are on overhang-

ing shaft, hub on feather key and double set screwed (mechanically correct) but the hub slipped, allowing blade casing to rub on steel case, and by either spark or flame, caused an explosion in fan, blowing iron trunking connection to dust collector and explosion continuing in dust collector and over third floor. The superintendent says explosion shook the whole building. They were prompt in shutting down and getting their own equipment into action. Also, the fire pump was started. The superintendent tells me the explosion appeared to fire the whole third floor, and fought the fire alone until the city department arrived. Everything above the roll floor was destroyed. About all that is left of the mill equipment is twenty-two stands of rolls (badly damaged), packers and one line shaft. The building is also badly damaged. About all the wood work and even the roller floor will have to be replaced. The walls stood fairly well. You cannot charge the fire to carelessness, for I think this fan hub slipped all at once and not gradually, as the exposed section of overhanging shaft shows perfectly bright, and little or no warning was given. It was just a plain mechanical accident, that at times cannot be avoided. The explosion would have occurred using any type of dust collector or dust room, but it is an open question whether fire would have issued with a Cyclone type of dust collector."

The early information received seemed indefinite and we submitted the series of questions referred to. The answers suggested that there might have been a possibility of the explosion starting in one of the rolls instead of in the fan. This wasn't cleared up until our recent investigation. The insurance adjuster made his report and assigned the fan as the cause of the explosion and the officials of the company agreed with him. That is explained in this way. The officials of the company in a case of this kind usually do not give out any information until after the insurance adjuster makes his report. Now they told us when this matter was taken up with them recently that this explosion could have started just as readily in the rolls. One of the superintendents told me one of the roll doors was blown open.

Mr. REED—In connection with the question regarding the proper installation of suction on the rolls, I would like to hear the opinion of the men regarding just where this suction should

be placed—above the roll—that is on the feeder, or underneath the roll, that is from a dust explosion standpoint.

Dr. BROWN—I think that while we might touch upon that now, that possibly Mr. Lind might bring that up in connection with his discussion of aspirating systems in the morning.

Mr. PRICE—I would like to ask some of the men if an explosion occurred in a roll, as the rolls are designed with doors, and the doors were blown down, would the explosion be of sufficient violence to reach into the collector?

Mr. BRADY—I knew of one instance where it went up into a dust collector and would have burned the mill were it not for the sprinkler.

Mr. BODNAR—I have had at least six millers tell me of dust explosions in the rolls and in only about two of these cases was there anything like a fire following. In all cases the doors were blown open, and in no case was it mentioned that the exhaust system was affected or that the explosion traveled through the spouts.

Mr. DEDRICK—In regard to the dust being drawn from above or below, it is usually the practice to make an arrangement to draw the dust from the hopper above. It is a little easier connected and perhaps is the best way, although frequently provision is made where it is connected below, taking from the spouts, and I don't know but that is just as good a way, only it makes more trouble to connect up. Now in reference to the explosions, I think that oftentimes what have been reported as explosions were pieces of iron going through the rolls. There have been cases reported where there was shock enough to force the doors open. There was no bright flash, only you could see sparks as you have seen sparks struck by a nail or a piece of metal going through a grinding machine. I have caught one or two pieces on the second break after passing through the first break. They press the rolls apart and these come together again making a noise similar to an explosion report. Personally, I never had an explosion on a roll, although I have come in contact with millers that have told me there was no possibility of iron or anything passing through and that they had a flash which opened up the door. Fortunately in these cases the explosion extended no further.

Dr. BROWN—As our time is getting short we will close the discussion on this explosion and take up the Manitowoc explosion. Mr. Brady has this subject.

EXPLOSION—ALUMINUM GOODS MANUFACTURING COMPANY, MANITOWOC, WISCONSIN

By PAUL E. BRADY

On Thursday, February 26th, 1920, at 10:55 a. m., the city of Manitowoc, Wisconsin, was aroused by a disastrous dust explosion which occurred within the plant of the Aluminum Goods Manufacturing Company. The blast was heard for a distance of two miles, and as a result of it six girls lost their lives, five more were seriously injured, some of whom may be maimed and scarred for life from the terrible burns inflicted upon them.

The property loss was very slight, although fire followed the explosion. It was readily checked by the efficient sprinkler equipment within the building, combined with the excellent work on the part of the employees who fought the flames until reinforced by aid from the city fire department. The plant was in full operation when the explosion occurred, and some 800 employees on duty. The accident happened on the third floor of the wing known as "C," in a room filled with some sixty workers, many of whom were girls. One part of this room is set aside for the department known as the "satin finish," and within the dust collecting system of this section the explosion was recorded. The finishers, all of whom were girls, were seated at their benches, when like a bolt of lightning, one blinding flash of fire enveloped them, and in an instant many were a mass of flames. The shrieks and moans of the dying and injured were beyond description, and confusion reigned supreme, as the living torches made their way to nearby fire escapes.

The plant consists of three large semi-mill constructed buildings, and one large brick and concrete building now under construction. These buildings cover an area of one solid block, and are designated as follows: Warehouse and office building, wings "A," "B," "C," and "D," and new building in construction. The warehouse and office building is five stories high, of brick and wood construction, and is used for the office, storage, and packing departments. Wings "A" and "B," and "C" and "D" are connected to the warehouse and office building. In these wings the different processes of manufacturing are carried on. The wings are three-story buildings, semi-mill construction. The company manufactures a complete line of aluminum ware such as teakettles, teapots, cooking utensils and all articles which can be manufactured from aluminum. The aluminum is delivered to the factory in sheet form. The metal sheets vary in size and gauge, ranging in width from 7 to 24 inches and varying in

length. Different gauge metal is used, depending upon the article to be made, and ranges from 30 gauge to 12. After the metal enters the factory it is given a light coating of grease. This application of grease aids in the handling of it, in preventing tearing and cracking while in process of cutting, punching, stamping and spinning. After the articles are shaped they are passed through a naphtha, lye, or acid bath, depending upon the article. This removes the grease and dirt. They then are dried, either by sawdust, which is applied by hand, or in tumblers filled with sawdust. Four different finishes are applied, different articles requiring different finishes. These finishes may be designated as high polish, satin, acid and emery. The high polish finish is applied by a buffing wheel made of cotton fabric. The buffing wheel varies in width, and is constructed in a manner to allow a free circulation of air through it. This type of wheel is used in preference to a solid wheel, in that it does not take fire as readily during the polishing process. In this process simply a tallow polishing compound is applied to the wheel, and when the article is polished a waste product is given off which is cared for by the suction in the hood surrounding the wheel. This waste, which consists of cotton particles, grease and aluminum dust, forms a sort of greasy matted product and is blown into a large dust house. Past experience of the company shows that since they changed the style of their buffing wheel in this department, that they have not experienced any trouble by fire in this suction system. Previous to this, when they used the solid buffing wheel, they had an occasional fire, but never experienced an explosion from this material. It appears, however, that the fine particles in this product will ignite readily, in that a test was made of this material and an explosion was recorded. The emery finish is applied by hand, a piece of emery cloth being applied to the revolving utensil. The acid finish is obtained by dipping the product in a vat of acid solution. The satin finish process is applied by scratching the article with a steel brush.

The cause of the explosion is attributed to a piece of No. 7 B & S iron wire winding itself around the blades of a blower fan. This caused a spark to be struck, which in turn ignited the fine particles of dust. This conclusion was reached after an examination was made of the fan by C. W. Keniston, representative of the State Industrial Commission, Madison, Wis., along with officers of the company. As soon as the explosion occurred, Mr. Keniston was ordered there at the request of the officers of the company. In the meantime

instructions were issued for no one to touch anything within the room where the explosion occurred. This was done that the industrial commissioner might have all evidence which might aid in solving the mystery. Mr. Keniston was the first to open the fan and found the wire within it. Just how the wire got into the fan seems to be a mystery, but the consensus of opinion of those closely connected with the investigation is that the wire came in from the outside. The exhaust pipe from the fan extended out through the window



View of dust collecting system showing wire as found in fan following the explosion. Buffing brushes used can be seen on bench.

and up to about five feet above the roof level, and discharged onto the roof. The company at the present time is erecting a new building adjacent to this, and various guy wires have been strung to the tops of numerous buildings about the plant. Whether through carelessness someone laid a piece of this wire on the mouth of the exhaust pipe, no one seems to be able to tell. The construction of the pipe leading from the fan to the roof is such that the wire coming in from the outside would have to pass through two turns of 45 degrees.

This being the case, it is quite possible that the wire may have been lodged in the pipe for some length of time, gradually working down by the vibration of the pipe, until eventually it was caught by the paddles of the fan and wound around same. Two girls within ten feet of the fan, employed at a wrapping bench, heard a noise within the fan just prior to the explosion. This noise was heard distinctly on two occasions previous to the blast. It appeared to be simply a rattle and one girl on hearing it got up from her chair and walked away from the fan. Two pieces of wire were removed; one from the fan and the other from the exhaust pipe. The supposition is that the wire was broken; one piece winding itself about the paddles, the other sticking in the pipe. The trunk line under the bench leading to the fan was cleaned out two months previously. Orders were to the effect that this trunk line was to be cleaned out every two months. The workman whose duty it was to look after the cleaning of this trunk line, advised that it was his intention to have cleaned same the following Saturday. He stated that at all times he used a cable in removing the dust and dirt from the trunk line, along with a wooden scraper. The wire found in the fan does not correspond to the cable which he claims to use in this cleaning process. He estimated that an average of about thirty pounds of dust and dirt is taken from the trunk line every two months.

A slight explosion is recorded at this plant in the same fan and suction system during the summer of 1919. A workman was engaged in cleaning out the suction system of the satin finish department prior to the time that the finishers came on for the day's shift. He had the fan running, and during the cleaning process the wire which he was using came in contact with the fan blade. This struck a spark, and an explosion occurred which broke open the trunk line where it entered the fan. After this occurrence, the superintendent instructed him that in the future this trunk line must not be cleaned while the plant was in operation. The workman advised that from then on he made it a practice to comply with these orders and generally cleaned the trunk line when the plant was down on a Saturday afternoon.

In the satin finishing department, some twenty-five girls are employed. This department is located in a room 200 feet long and 50 feet wide. It occupies a little over one-third of the south end of the room, while the balance of the space is used for the dipping and wrapping departments. Some thirty

other people work in the room, but all the employees burned or injured worked in the finishing department. Nine lathes were used in the satin finish process. These machines were placed on a long wooden bench, and two girls employed to a machine. The machine consisted simply of a spindle 30 inches long, on which was placed a steel brush at each end. The satin finish or scratch finish was applied by placing the aluminum ware against the revolving steel brush. During this process fine particles of the aluminum are removed. This creates what is known as aluminum dust, and for sanitary reasons a suction system was installed to aid in the removal of this dust and prevent this large room, with its many workers, from being compelled to inhale it.

Surrounding the brushes were hoods connected by a 3-inch pipe to a main trunk line. This trunk line averages 12 inches in diameter. It was connected to a 36-inch suction fan with a 16-inch opening, and drew the dust from the various machines and discharged it to the atmosphere outside. The trunk line extended underneath the bench and varied in diameter from 6½ to 16 inches. The fan was constructed of steel and had a steel casing. It had a speed of 700 R. P. M., and discharged through a 12 x 12 opening. The first three machine hoods were connected separately to the trunk line, while the balance, or six machine hoods, were connected in pairs, one trunk leading from the trunk line and then separating, one line each to the hood. Such a connection seems to lead to the supposition that the girl to the left of the machine was invariably the one most severely burned. This is due to the fact that a connection of this type had a more direct entry from the trunk line to the hoods of the machines, and when the flash occurred the flames more readily entered the left hood.

The report of the explosion was heard for a distance of two miles. No damage was reported to outside property. Owing to the large window area of the room in which the explosion occurred, the force easily made its way to the outside. It is quite probable had this plant been equipped with little window space, that the side walls, which were bulged, no doubt would have given way entirely. Three doors were blown off their hinges, and one oil can blown into the ceiling. It appears that this can went straight up, as the spout of the can stuck into a crack in the ceiling.

The following recommendations were made: The suction

system on a satin finishing system should be such that no dust would accumulate in any of the suction pipes. The system should be so constructed that there would be no accumulation of dust at all. In the system that was in use, some thirty pounds of dust would accumulate in the main trunk line every two months. This brings out the fact that maybe the fan was not large enough to clear the size of pipes that they were using. A smaller trunk line, no doubt, would have been kept clean with the size of fan they were using. Where dust is allowed to accumulate like it did in this trunk line, it simply adds ammunition to a blast should a spark be struck within that system. Experience shows that no wire should be used to clean out a trunk line of this nature. This company experienced a minor explosion from this source about eight months previous to this one. It would seem practical to run a trunk line handling material of this nature overhead of the machines instead of along the floor. In this instance the trunk line ran along at the feet of the operators, and the blast blew part of it to pieces, giving the flames a chance to envelop the workers very readily. Had this trunk line been up above the heads of the operators some six or eight feet, it is possible that the flames might not have reached them so readily as when they burst forth at their feet. We believe it advisable to perhaps cut down the units in such a way that instead of having one large suction system to handle all the machines, that more individual fans be used to a unit. In other words, make separate units. It might be desirable to place the fan near the ceiling above the trunk line, so that the current of air entering it will always be drawing up. This might eliminate the danger of a piece of metal being carried into it and striking a spark.

Mr. BATES—What was the material of the wire found in the fan.

Mr. BRADY—It was iron wire.

Mr. PRICE—I saw the wire at Madison. It was thicker than telephone wire. It might be used in connection with construction work such as they were doing.

Dr. DUVEL—It has just occurred to me; would it not be worth while to have an analysis made of that wire?

Dr. BROWN—It might be to determine accurately the type of wire; I am sure we would be glad to have it done.

Mr. PRICE—The Wisconsin State Industrial Commission is now preparing a report and when that report comes in, the information will practically be covered.

Mr. BATES—I have not been able to satisfy myself as to a metal like this exploding. I cannot understand how aluminum dust under any condition would cause an explosion. I would like to see one.

Dr. BROWN—Come up to the laboratory and we will show you.

EXPLOSION IN FEED MILL AND ELEVATOR, CURTISS GRAIN CORPORATION, BUFFALO, N. Y.

By H. J. HELMKAMP.

This explosion occurred September 12, 1919 at 5:23 P. M. resulting in injuries to three men and property damage to the extent of about \$20,000. The plant, which was of brick construction, consisted of the following units: (1) a 3 story warehouse, (2) a 5 story building used as mill and elevator, (3) a 2 story structure used for making molasses feeds, (4) a 1 story warehouse for bag storage, (5) offices (of wooden construction).

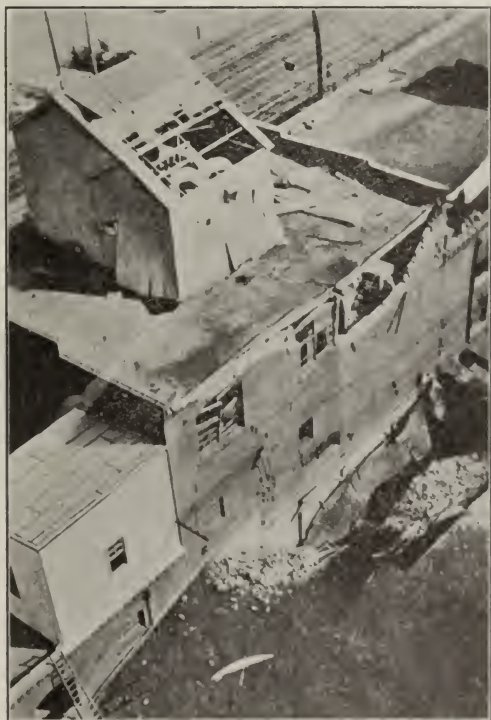
In unit No. 2 the grinding was done on the first floor. From the second to the fourth floor were crib storage bins and one large metal scale bin extending from the second to the fourth floor. The fourth floor was used as a bin floor and was equipped with the cleaning machines. Lofters heads were on the fifth floor, also a receiving separator and cyclone dust collector.

Plant was used for the storage of grain both in sacks and in bins and for the manufacturing of mixed feeds and molasses feeds. The elevator was equipped with two lofters, one for receiving and one for loading out grain. The elevator process was similar to other plants of this type. The investigation showed that the outside of the elevator legs and the outside of the man lift were scorched. Flames seem to have traveled up around the metal scale bin to the fourth floor where the explosion occurred. The force of the explosion blew out part of the west wall on the fourth floor and blew off part of the roof of the lofters room at the top of the building.

The point at which the explosion originated or its cause was not definitely determined. One theory advanced was that the muslin cover around the motor on the fourth floor was ignited

by a spark and the flash communicated to the other floors through the various openings. Upon running the motor, however, two days later, for a period of two hours, it was found to operate satisfactorily.

Other theories, such as the explosion originating in the elevator leg and also the possibility of a workman striking a match while preparing to leave the building, were advanced. The greatest damage, however, was done at the top of the building, which would indicate that the explosion might have traveled in that



Damage to upper floors resulting from dust explosion
in a feed mill.

direction. The burning of the muslin cover over the motor on the fourth floor might have been caused by the fire accompanying the explosion. From evidence obtained at the investigation it is believed that the fire started from some unknown cause on the first floor near the loftier leg and propagated up to the fourth floor about the metal scale bin and upon reaching this floor ignited the dust that was in suspension in the air, thereby causing the explosion.

Dr. BROWN—Is there any discussion on this explosion? If not, there is one man from whom we would like to have a few remarks, and that is Mr. Boerner, who has been associated with us in the Department of Agriculture. We have had very pleasant associations with Mr. Boerner's staff in the Supervision Offices throughout the country. I am sure we would be glad to have a few remarks from Mr. Boerner.

Mr. BOERNER—Mr. Chairman: I have been listening with a great deal of interest to the discussions. There are a great many features brought out in the work which are worth while getting to the people. When you were talking a while ago about the educational phases, of the need of getting this work to the high schools, it occurred to me that one source that was not mentioned was that of the grain supervision force of the Bureau of Markets. They are constantly working with the elevator people, and some of them who are specializing in particular lines of the work, are at the elevators entirely, and it would be doing a lot of good to get this work to these people. The whole problem is of interest to our grain section of the Bureau of Markets. I am connected with the investigational work, and we are planning this coming year to take up the question of elevator construction design; not so much the question of detailed specifications, but general problems involved, especially in the Pacific Northwest where they are changing from bag to bulk system; and apparently they should not forget this dust explosion prevention work. Surely that is a pertinent feature in making up our designs, and there is no question but that there would be a great deal of use for it. Our office is receiving requests every day for designs. If we had this in shape so that we could use it in that connection, we would make very good use of it.

Dr. BROWN—I am sure we appreciate Mr. Boerner's remarks. I might say we have been making more use of these inspectors than Mr. Boerner realizes. It has been my experience in holding our special meetings, that the supervision officers have been counted on in getting the people to the meeting, and the supervisor particularly. In many cases they have had their entire force at the meeting. I am sure we will be pleased to accept Mr. Boerner's kind offer to extend the activities through this force to get information to them. For your information, I might state that we are anticipating getting out a couple of publications shortly, and we would be glad to have them distributed to all of these men.

We have two other explosions to consider this afternoon, and I

will ask Mr. Riley to tell us about the explosion at the "H—O." Mill at Buffalo.

"H-O" MILL EXPLOSION AT BUFFALO, N. Y.

By E. L. Riley.

This explosion took place the 21st of November, while certain changes were being made in a steel leg located between two steel tanks. The only opening in the boot of this leg was a small hand hole at one side and when the leg became choked, it took some time to clear it, due to this small opening. The superintendent on the day following a bad choke in this leg, gave instructions to the millwright to cut a square out of the front of this boot and place a slide in there, so that the leg could be easily cleared, if another choke should occur. The millwright, thinking it perfectly safe, had a man bring an acetylene outfit in, to burn this square out of the boot and while this man was engaged at this task at the boot of the leg, another man was at work at the head of the leg removing a short spout leading from the head of the leg to a steel conveyor. The top of this leg had been removed so that the man working on the spout at the head of this leg could see better. The man at the boot, after burning the square far enough through as he thought so that a few taps of a hammer would knock it out, extinguished the acetylene torch and was coiling up the hose, preparing to depart, when one of the men started to hammer on this square, intending to knock it out. At the same time the man at the head of the leg started to hammer on the short spout that he was trying to remove. An explosion, or in my opinion, two explosions took place at this time, that wrecked this 75-foot steel leg and burned three men at the boot of the leg and one man who was working at the head. The explosion or explosions, went upward through the back of the leg and burst the steel housing for a distance of about 30 feet, starting at a point about half way up the leg. It is my opinion that a small explosion took place in the boot when the dust accumulation there, which had become ignited by the intense heat from the acetylene torch, was thrown into suspension by the hammering on the boot, and the flames from this first explosion shooting upward came in contact with the dust cloud created by the man hammering on the short spout leading from the head of the leg, and another explosion took place, this last explosion bursting through the steel housing and doing the most damage. I believe this explosion will be the

means of preventing a similar occurrence at this plant, for it has proven our contention that open flames should never be allowed in any part of a mill or elevator, due to the existing hazard of dust explosion and fire in these plants.

Dr. BROWN—Is there any discussion on this particular explosion? I am sure it is an interesting case and one on which we could get quite definite information.

Mr. RILEY—I might state that three men were burned at the boot, and one man working at the top was more or less seriously burned.

Dr. BROWN—An interesting fact brought out in that explosion is that the top of the elevator leg was open, still the explosion occurred and blew apart a portion of the casing. Is there any other discussion on this subject? If not, we will ask Mr. Riley to discuss the explosion at the Spice Works in Cincinnati.

Mr. DEDRICK—It would seem that if the leg were open all the way that it would give it an opportunity of getting a vent; that the pressure would go up, particularly on the back of the leg with the buckets down would make it more obstructive than if it had been in the front of the leg.

Dr. BROWN—Any other discussion on this explosion?

Mr. BODNAR—That case makes me think of the possible fact that small openings or vents in bins would hardly be effective enough to prevent building up of pressures, i. e., that the pressures would be strong enough to blow bins apart as in the Port Colborne explosion, and the elevator construction that I illustrated the first day would seem to me to be a better method of venting bins than merely by means of a small pipe vent. Mr. Riley's explosion there made me think of that, and I thought it would be well to bring this idea to your attention.

NEWTON TEA AND SPICE COMPANY FIRE, CINCINNATI, OHIO, JAN. 17, 1920.

By E. L. RILEY.

On January 17, 1920 four firemen were killed and thirteen injured, when apparently an explosion in the burning mills of the Newton Tea and Spice Company at Cincinnati, Ohio, blew out the east wall of the structure. Firemen had been fighting the fire for approximately thirty minutes before this wall fell, and facts

brought out at this investigation lead us to believe that this plant had been burning for hours before being discovered. I do not believe that this fire started from a dust explosion or that the explosion was due to the dirty condition of the plant, for reports of the Ohio Inspection Bureau show that the plant was in clean condition at the time of their last inspection. The ground spices, after coming from mills, were stored in wooden barrels and I believe that these barrels of spices, which were uncovered, fell with the floor on which these barrels were stored and the resulting clouds of spice coming in contact with the flames caused the explosion that blew out the wall on the firemen.



Fire and explosion at plant of Newton Tea and Spice Company, Cincinnati, Ohio. At extreme right can be seen bridge from which firemen were fighting the fire when the wall was blown out by explosion of spice dust.

Dr. BROWN—Are there any questions or discussion regarding this explosion? If not, I think this will close our program for this afternoon. We have a pretty full program for to-morrow morning. We did not get time to finish all we had for today because we did not get here on time, so I am going to ask you to get here by 9 o'clock so that we may get started promptly.

Meeting adjourned until 9 a. m. Saturday, April 24.

SATURDAY MORNING SESSION, APRIL 24, 1920

E. N. BATES, Presiding.

Mr. BATES—The first paper this morning is, by Mr. Witmer, on the subject of "Suction versus Bucket Elevating in Handling of Grain."

"SUCTION VS. BUCKET ELEVATING IN HANDLING OF GRAIN.

By GEO. D. WITMER.

The method generally employed today for the handling of grain in this country is by bucket, conveyor and spout. By choke-ups, friction and hot journals, the bucket elevation has been the cause of a number of plants being destroyed by fire and explosion. On the working floor where the grain is removed from the car, it is generally dropped a distance of from 4 to 6 feet, and at this point a large quantity of dust escapes, becoming suspended in the air and finally lodging on beams and ledges. While moving a large quantity of grain by this method, the air becomes extremely heavily laden with dust and the working conditions are bad. It is possibly due to these bad features in connection with handling grain by bucket elevation, that the air conveying method is gaining prominence and is favorably looked upon by some of our grain men.

In Europe more than sixty per cent. of the import grain is handled by suction. In this country only a very small quantity of grain is handled in this way.

The pneumatic or air conveyor is simple in construction. There are two principles: One is suction and the other pressure. Where suction is used, a partial vacuum is maintained within an enclosed tank by a motor driven exhauster. The conveyor ducts which are provided with flexible intakes or self feeding nozzles, lead from the car or vessel to the tank. The high velocity of the air blast within the duct conveys the grain which when reaching the tank becomes released and drops to the bottom, discharging through a rotary discharge gate directly to the storage bins, or may again be blown to some other part of the building by utilizing the air blast from the discharge side of the exhauster. In this second operation, however, pressure would be used instead of suction. A dust collector may be installed and a complete separation made of the dust and air which is given off by the exhaust from the vacuum tank.

With the suction method the grain is drawn directly from the car or vessel and delivered to any part of the building. The distance the grain may be conveyed depends entirely on the amount of power used. One elevator company which uses both the bucket elevator and suction system for the elevation of their grain, makes the following comparison in relation to capacity: A 100 H. P. electric motor is required to operate their bucket elevators and another motor of the same size is attached to the suction system. During an hour's run on wheat, the elevators handled 15,000 bushels and the suction 2,500 bushels, or one-sixth the capacity of the bucket elevators.

Due to the automatic nozzles used in connection with the suction system, several outstanding points are worthy of consideration.

Cars are unloaded without the removal of grain doors.

It eliminates power shovels in cars and the holds of vessels.

It eliminates waste and thoroughly removes all grain.

Makes possible a close separation between wet and dry grain.

Makes it possible to remove grain from a vessel in rainy weather.

Eliminates danger of damage to a small vessel, or barge, by accidental lowering of the heavy marine leg, or from the vessel riding on the wash of passing steamers.

Betterment of labor conditions and eliminating, to a great extent, the dust and fire hazard.

The Pressure System, which may possibly be called a grain blower, is not intended for the removal of grain from a car or vessel; but when the grain is delivered to its hopper or supply tank, its work is similar to that of the suction system, with the exception of the suction nozzle. The grain when spouted or delivered to the hopper, passes into a spiral conveyor which carries it upward at an angle of 45 degrees, and feeds it through a valve into the blower discharge immediately underneath. From this point the grain and air travel through an air duct to a receiving tank or cleaner which may be located above the storage bins or any other part of the building, where the grain is intended to be delivered. There are no moving parts in the receiving tank that operate mechanically and its operation is similar to that of a cyclone dust-collector. The chaff, dirt and dust, being lighter than the grain, will not have the same momentum, and after entering the cleaner will immediately become separated and travel with the air through the discharge to the outside. The grain being heavier will drop to the bottom and pass through an

opening or spout to storage. Should it be desired to collect the chaff and dirt escaping with the air, a dust-collector could be installed and this material again recovered.

A grain blower may be installed inside or outside of a building and may be portable. It will convey or deliver grain from one building to another, from elevator to mill, from wagon to storage, and may be used for the loading of grain into cars. All that is necessary is to connect a pipe leading from the blower to whatever place the grain is intended to be delivered. The capacity of a grain blower, like the automatic suction, depends entirely on what kind of grain is handled and the distance, and height to which it is delivered.

In the movement of grain with either of the above mentioned methods, wheat and rye require the most suction and pressure. Corn, although weighing a little less, is handled much faster with the same speed and power. Oats, being much lighter, handle still faster than corn. The reason for this difference is that the corn kernel is much larger in size than wheat or rye and, therefore, has a much greater area exposed to the air blast.

Elbows in the air ducts or pipe lines should be avoided wherever possible and, when necessary, should have a long, easy curve so as to give the least resistance to the passing grain. Grain in the air duct travels at a great velocity, and in striking a short curve or elbow will have a tendency to rebound. To overcome the rebounding and the extra friction consumed in forcing the grain through the elbow at its initial velocity, it is necessary to have increased air pressure or suction, and this means an increase of power.

Grain generally is in such a condition that it could be improved upon every time it is handled. The time is long past when grain in poor condition will bring the same price as that of a No. 1, therefore, the improving and conditioning of the grain in a simple way should be of importance. When grain is conveyed by either the suction or blower method, we might say every time it is handled, it receives an airing, cooling and cleaning.

Mr. BATES—This paper has been of particular interest to me as I have made some little study of this question of handling grain by the different methods and it certainly is a well prepared paper, and the advantages enumerated seem to be very complete. I was interested in comparing the figures that Mr. Witmer gave for the elevation by suction with figures I

recently saw in a magazine, in which they claimed that the European pneumatic elevators required about one horse power per ton of grain handled per hour, which seems to be a fairly general rule. Twenty-five hundred bushels would be a little less than one hundred tons. These elevators, I believe, mechanically are very inefficient. As I estimated the height to which they would raise the grain, the elevator on which I figured was about ten per cent. efficient. A certain pneumatic farm elevator on the market is a combination of suction and blowing. They suck the grain out of the wagon box or from whatever they are taking the grain, run it through a revolving chamber and then by the blast of the fan blow it into the bins. I believe this machine worked out about $7\frac{1}{2}$ per cent. efficient. It would look as though the air suction method was a rather expensive affair as far as mechanical energy is concerned, which is exactly true. It is just a question of whether that cost of power outweighs the flexibility and desirability of having your grain handled that way. We have a few minutes more for discussion here.

Mr. PRICE—The method applied by engineers in the suction collector was discussed last year at our Chicago conference. We recently witnessed a demonstration of handling materials in which there was a great deal of foreign substance. The dust-collector was between the source of collection and the fan. I should like to ask Mr. Witmer whether from his observation of a system of this kind in some of the eastern industrial plants, he feels that it might be extended to the handling of grain?

Mr. WITMER—Possibly it could. These machines are giving satisfaction on the handling of pulverized materials, in fact any material where it is desired to collect or recover the dust, such as lime, ash, fertilizer, etc. But this material handles considerably easier than wheat, rye, or corn. Wheat and rye are the hardest materials to handle and require a great amount of power. In the handling of grain an ordinary cyclone dust-collector would possibly be used instead of the long cloth tube recoverers used in connection with the handling of pulverized material.

Mr. PRICE—It has become apparent that dust has a commercial value per pound. The laboratories have been testing samples of elevator dust which we understand they find are of

high grade or high rating for cattle feed. It might be some inducement to recover the dust.

Dr. DUVEL—I don't remember the figures we have had, but we have had a number of samples analyzed and they are valuable. Every time I go around an elevator I can't help but feel that the waste of valuable material is excessive. That is one reason I am particularly interested in this dust-collecting question. I think that the time is coming when there will be dust-collecting systems on elevators as they unload the cars, regardless of the attitude taken by state-weighmasters and other state officials. Some method is going to be provided to take out dust and make suitable working conditions wherever we have dust. It should not be wasted. That is one thing elevator people don't realize. It is the same thing you get back to by putting cleaners on threshing machines. As the farmer has the dirt taken out he doesn't worry about it. That is one reason I have always been opposed to a modification in the wheat standards, raising the dockage to one per cent. There is no inducement to remove the dust.

Mr. HIBBARD—The market value of elevator dust at the present time is five to eight dollars per ton. One plant in Chicago produces 8 to 10 tons per day.

Dr. BROWN—It was my pleasure some time ago to visit and see in operation one of these types of installations of which Mr. Price has spoken, and while that was being used for the handling of fertilizer products, as for instance ground tankage and other substances used in the making of fertilizers, the man who was operating it had been over two years in an elevator and knew something of the problems of handling grain. He felt that that system would be very effective and operate very efficiently in the handling of grain. One objection which has been raised to that—I don't know whether it is altogether real or only apparent—seems to have been to the fact that the grain goes in straight, perpendicular to the diameter, we might say, and strikes against baffle plates on the far side, the feeling being that in so doing the grain would be broken and the abrasive loss would be great. This man felt that that was not an objection because the grain was not moving at a velocity comparatively speaking any higher than the velocity attained in dropping it into deep pits or other types of apparatus where the grain is really thrown some

distance. However, he did raise the question of mechanical efficiency. He felt that the installation as used there was really too expensive to pay for itself in operation.

Mr. WITMER—In the installation that I looked into, the receiving pipe entered at the side of the tank and the grain was hurled around the interior and did not bank against itself.

An elevator in the neighborhood of New York, until recently, had been dumping their dirt into the harbor. The plant recently changed superintendents. The new superintendent now gathers the dust and fine particles of grain and separates them, although he does not sell the fine dust, he is selling the fine grain and says he is able to get top notch prices for it. There is a concern in Baltimore that is getting \$11 a ton for their grain dust.

Dr. DUVEL—Other people mix a little molasses with it and get \$40 a ton.

Mr. BATES—The attraction between this crowd of men and dust is something I can't break down. We are supposed to be discussing grain handling problems but you always seem to find something to say about dust.

I remember an incident that occurred in New Orleans where weevily wheat was being unloaded at the public elevator by a suction system and strange to say when the wheat was delivered there were no weevils in it and though they were sure that weevils were going into the elevator pipe none were coming out. Finally by microscopic analysis they found fine particles of the weevils' anatomy in the dust. The weevils were being crushed by the impact of the flying grain which shows another conditioning effect of this type of elevator.

"RELATION OF ASPIRATING SYSTEMS IN GRAIN ELEVATORS TO DUST EXPLOSIONS."

By W. B. LIND.

What is an aspirating system in a grain elevator? It is a system of dust collectors and galvanized steel piping, by which the dust is taken from the elevator boots, garners or scales, floor sweeps and the various cleaning machines, and delivered automatically to the boiler furnaces, as fuel, without the loss of any grain, thereby keeping the elevator clean, utilizing the dust, reducing the insurance rate, and preventing dust explosions.

THE PRINCIPLE OF DUST COLLECTING.

The separation of dust from the air by the revolving movement of the air, and throwing the dust out of the revolving current because of its greater specific gravity, is a well-known principle, and is the method chiefly used in dust collecting systems operating in grain elevators.

1. To keep a grain elevator clean is a problem that worries the elevator man, and a dust collecting system solves this problem in a most satisfactory way. However, its efficiency depends entirely upon its installation. The amount of work it has to do varies and is determined by the number of points from which connections are to be made, and unless all tributary and main trunks are, as to size, in unison with the size of fan and amount of work to be done, the system becomes useless. It is, therefore, very necessary to get the best results, that a dust collecting system be properly planned and installed with a view to the work to be done and the conditions in each case.

2. Points of application in the minds of those familiar with aspirating systems as used in elevators differ in a great number of cases, as it must be remembered that nothing of any value is permitted to be removed, and it has been demonstrated that points where aspirating systems could do the most good were at points that would not meet with the approval of various state and warehouse commissions. It being their contention that some of the principal from which the dust was to be removed would also be carried away, thereby developing a loss greater than would be the good derived by eliminating hazards brought on by dust accumulations. There is present, however, a difference of opinion in this particular phase of the question, as I have been advised in numerous instances by superintendents of different elevators in the Northwest that the amount of principal, should any be removed, is of minor consequence. Not enough if any would be lost to make a material difference, and that between the loss, if any, and the dangers that would be present from the dust hazard, the latter is by far of a greater importance.

3. Where aspirating systems have been applied at such points as are considered by a warehouse commission and state weighers as a point from which a loss may develop, the removal of such systems from that particular point or points was ordered and as a consequence there are a number of elevators that are not operating their aspirating systems, being forced to abandon

them. Consequently the elevator becomes easy prey to dust, and the hazard is therefore as dangerous as is the case in an elevator without a dust collecting system.

4. In order to get the best results from an aspirating system it must be seen to regularly. Very often connections become separated, main trunks and tributaries by some means are punctured, this causes air to escape and also permits dust to escape, the latter settling about plant again. The loss of air under these conditions is of much importance. If there is not sufficient air pressure behind the dust in main trunks and tributaries, dust will then settle throughout the entire trunking systems. Should this condition exist and some form of ignition develop within aspirating system, and enough of this dust brought to suspension, disastrous results would be sure to follow. Propagation would be very rapid and would effect entire trunk line, resulting in perhaps loss of lives, vast property damage and loss of food.

5. It is interesting to know, even though most elevators are equipped with dust collecting systems they are not always as free from dust as are some plants that have no aspirating equipment. There are several reasons for such conditions, first, application of systems at improper points; second, system not in accordance with equipment it is to serve, little attention perhaps having been given to trunk size, fan size, speed of same, distance dust must be carried and elbowing; third, lack of interest by superintendent and help about a plant in hazards arising from dust accumulation.

6. In bringing out more clearly this latter statement, I can cite instances where aspirating systems are installed but not regularly in use, as a consequence dust is in evidence throughout plant in considerable quantity. This would not be the case had collectors been in operation. I have seen dust in piles about the floors of elevators; a floor pick-up trunk would be close by and a few strokes from a broom would bring this dust pile to intake opening of pick-up trunk and by applying power to fan same could be removed very rapidly; but, instead of removing at once, it would remain for three or four days more. In the meantime, that same pile of dust may be the cause of total plant destruction, life and food. Just such conditions demonstrate most forcibly the necessity of daily dust removal after each day's run.

7. All grain elevators, whether equipped with aspirating systems or not, should have enough help sweeping regularly to insure dust accumulation removal from parts of plant inaccessible

to dust collecting equipment, such as spout tops, bin edge tops, ledges, underneath belt conveyors, and any other parts impossible to reach with mechanical collecting equipment necessary to function properly.

In conclusion, will say clean elevators: (1) Reduce the fire risk; (2) Give better working conditions for the employees; (3) Prevent dust explosions; (4) Reduce the possibility of injury to person and property, and liability to damage suits; (5) Save that which it is impossible for the human body to exist without, Food.

SYSTEM OF INDIRECT SUCTION.

We have what is known as (and same is now being installed in several elevators in Minneapolis), an Indirect System of Suction. Some of you are familiar with this I, presume.

This system consists of the building of a trunk line of wood or galvanized iron on outside of garner wall, with intake opening connecting at top of hopper scale and outlet opening from roof of garner into an indirect trunk line to a main trunk leading into a fan. The idea is that when feed gates of garner are opened and grain drops into hopper scale, the air is forced up and carries dust with it. The dust is led through inside top of garner to an opening in garner roof and then to a trunk connected indirectly with a fan as above described. Another connection can also be used that leads to an opening to down leg.

The object is, as relating to down leg connection, by the suction created by belt cups, to draw the dust with aid of air therein created to bottom of leg or boot, and when it gets into the boot, there is another independent connection which extends over the outside of both sides of boot and is connected to a trunk between legs which is also connected to a fan that draws this dust into cyclone inside or out.

This system is called indirect because it is not directed on the grain proper. With reference to connection on garner head or roof, it has a short trunk extending up possibly 6 or 8 inches. It is 4 feet between the wheat line and roof of garner. The object is to extend this connection as far away from the grain as you can. It is then disconnected, leaving a space of four or five inches; a bell-shaped hood with a larger circumference than the trunk, is attached over this short trunk.

There is an installation of this type in the Crescent "H" Elevator in Minneapolis, but the method of installation just described was not strictly adhered to; instead the hood was

brought down flush with garner roof. This connection is much more effective but when it was found they had made a direct connection they were ordered to remove same and went back to the plan referred to. In applying fan to trunk line it was found very ineffective; because of the distance between short trunk, and hood being open dust would escape, also air, and the dust would then settle on roof of garner and also on garner floor. It is for this reason that they have stopped any further consideration of that system in the balance of their garners. They hope to determine very soon the advisability of bringing funnel or hood flush with roof of garners by taking the matter up with the state officials. If this can be done the system will be installed on all garners, but if not, then no further consideration will be given it by the Crescent "H" Elevator.

I don't know whether it will be successful or not. The weigh-master advised that it would not be unless same could be built flush with garner roof and eliminate the open space between short trunk from garner roof to funnel or hood. It has been tried both ways in this plant and found to work very well as, here described, and no loss of any grain was noticed.

The system not being generalized, I believe, this is as much as is known of it at present.

Mr. BATES—Is the method devised to remove as little dust as possible from the grain?

Mr. LIND—Yes, and in its present form very little dust will be removed.

Mr. PRICE—Is it a case of removing as much as you can without removing very much?

Mr. REED—It looks to me that if they ever do have an explosion in a system of that nature they are going to have a real explosion. More dust is being added all the time and there is no chance for any of it to escape. There would be every chance possible for flame propagation.

Mr. PRICE—We feel that the various State Commissions have certain grounds for the position they take regarding the use of aspirating systems. An official in a Western state has been impressed as a result of a recent explosion in that section. We had the same experience in Canada. It happened in the explosion at Port Colborne that the aspirating system was not operating, because its use had been prohibited. Our feeling is just the same as it always has been, and this is a question

which should be gone into at the earliest opportunity and settled. We should work out a code regarding the points at which aspiration can be applied, together with size of fans, points of suction, etc., necessary. I am a little afraid that the indirect suction method designed is not going to accomplish what we have in mind. I think it is way ahead of what the commissioners have considered up to this time and some of the state officials have changed their ideas. I had a conference with some of these men recently in Chicago. I found that they were very free to discuss the matter but were strong in their position. They cited cases where the privilege had been abused and they are perfectly willing, I think, to work out some arrangement whereby this entire matter can be handled if it is to be on a basis of definite control.

Mr. HELMKAMP—One of the officials I have met, I think, wants to see this hazard reduced as much as possible. He is in favor of suction of some kind being applied. He asked if it was possible to put a glass tube in whereby the weighmaster could see that none of the grain was being sucked up at any time. The suction stream could be observed by the weighmaster.

Dr. BAILEY—In fairness to the Minnesota Commission I might state that I believe the commission itself is favorable to the idea of installing proper dust collecting systems in the elevators, but they have been forced to bow to the weight of public opinion in the matter, which a few years ago was thoroughly aroused by certain situations, which more or less justified suspicion. If the Department can evolve a system or code which involves such mechanical installations as will make impossible improper manipulation by the elevator operators, I believe the Commission will be prepared to indorse it and insure its more or less universal adoption in the elevators of Minnesota.

Mr. BATES—We have to realize that we are living in a political organization where the majority usually have their way. The sooner we realize that we can just work our heads off so far as technical work is concerned if we don't get the support of the public, our work will count for little. It seems to me that the thing needed more than anything else is, you might call it, propaganda, to show the value of dust; to prove to these people who are taking such a narrow view of the situation that they will actually receive more money by removing their dust and selling it as dust, and point to the other advantages as well. I believe that if we can make the elevator

man and the little grain dealer see the advantage of this the big man is bound to come around. All political activity, I believe, comes from the masses, or should. We ought to give more publicity to the work we are doing in dust collecting and force these operators to permit aspiration as apparently they are willing to permit dust collection if the people want it. The danger of removing grain with the dust, is, I believe most everyone will realize, a purely imaginary difficulty. We find in thresher work, that a fan to do fairly good cleaning with an aspirator requires a very high velocity in order to lift the heavier particles from the grain. A glass peep hole in a suction tube would be of no use, for of course, the grain is going pretty fast. Usually when it gets a start you wouldn't have an opportunity to observe whether it was a kernel of grain or something else when it goes up through in the glass tube, or window.

Mr. PRICE—I just want to take a minute to clear up our position. I think we enjoy a position of distinct advantage over the State Commissions as far as publicity is concerned and we might abuse that advantage. The State Commissions have not resented what we have said in public but they told me that it has hurt them just a little because we have come out definitely and said that we might prevent these explosions if aspiration was applied and asked me upon what foundation that statement was based. Of course, to answer a question of that kind before a commission is difficult. It is assuming that we are going to take out a certain amount of dust that might settle and be propagated from a primary to a secondary explosion. My own feeling is that beyond question aspiration should be applied, but we have got to be just a little cautious until we can work it out pretty definitely.

Mr. BATES—I am sure Mr. Price has proved himself a diplomat many times. It will be well to take his remarks with a great deal of consideration. The next paper is by Mr. Helmkamp relative to a novel or new method, or process which he has run across in his wanderings.

A SYSTEM OF AIR PURIFICATION IN FLOUR MILLS

By H. J. HELMKAMP.

In the southwest recently it was my pleasure to inspect a system of air purification which was installed in one of the flour mills in that section. The process is a system whereby

washed air is provided to the purifiers, reels and rolls, throughout the manufacture of the flour. A machine washing 25,000 cu. ft. of air per minute is used. This machine is located on the second floor.

The air is washed in this air-washing machine and by means of baffle plates the moisture is precipitated out. By means of small sprays sufficient moisture is then added to the air. By means of large ducts and pipes the washed air is then furnished to all the purifiers, reels and rolls. The machines to which this air is furnished are made practically air tight so that only this washed air comes in contact with the stock.

Some of the benefits that result from this installation are as follows:

First: Since only pure, clean, washed air comes in contact with the stock, the stock is kept free from any dirt and dust that might ordinarily be in the air of a flour mill. Thus a cleaner product is made.

Second: The air throughout the mill is cleaner inasmuch as it is being continually washed. At the time of my visit the air seemed to be exceptionally pure and free from dust. Thus the danger of dust explosion is practically eliminated and the working conditions made much healthier for the workmen.

Third: The time for tempering the grain is reduced to about six hours. The moist air keeps the stock uniformly moistened throughout all the mill streams. This reduces the number of tempering bins.

Fourth: The air in the mill is kept cooler at all times than the machines, which is necessary for good milling.

Fifth: The life of purifier and bolting cloths are lengthened. This is because this blue-blackish dust never comes in contact with the cloth.

Sixth. Ash in the product is reduced because the stock is moist at the tail of the mill and consequently pulverizing is prevented. In the ordinary process of milling moisture is given up so that the finished product has possibly three per cent. less moisture than the wheat entering the mill. This loss is known as invisible loss. So it is evident that the stock at the tail of the mill is quite dry and naturally pulverized more readily. By this process the stock is kept as near as possible to the same per cent. of moisture and thus pulverizing

of stock at the tail of the mill is reduced and hence the ash is reduced. In addition to this it is evident that the invisible loss in milling is less.

Below is the average of a large number of laboratory tests made before and after the process was installed.

	Moisture of wheat entering mill. Per Cent.	Moisture of wheat on rolls. Per Cent.	Moisture of Product. Per Cent.	Moisture Loss, difference wheat over rolls product. Per Cent.	Ash, Straight Grade. Per Cent.
Before	9.9	15.6	12.8	2.8	.49
After	11.6	14	13	1	.43

In conclusion, I might say that, first, a purer and cleaner product is made and, second, the air throughout the mill is kept clean and practically free from dust, thus reducing the dust explosion hazard.

Mr. BATES—A very interesting paper. I don't know how well we are equipped to discuss it, but will be glad to hear any remarks.

Mr. PRICE—I think this is an elegant opportunity for our flour milling men to discuss this. Mr. Helmkamp thinks it is effective in explosion prevention. This is the first time it has been brought to our attention. We would like very much to have your opinions.

Dr. BAILEY—This is a sort of modification of an English process known as the Humphreys Process in which they introduce the water right into the machines themselves. Now, from the description given by Mr. Helmkamp, I assume that this air treating device, in addition to washing the impurities out of the air also humidifies it.

Mr. HELMKAMP—The air is taken in and washed, the excess moisture precipitated out. By means of sprays moisture is then added to the air.

Mr. BAILEY—If the air is washed, even though an effort is made to precipitate out the water globules, it would be pretty well saturated with moisture. From my knowledge of the use of similar appliances in the milling industry I might suggest that humidifying the air, rather than removing the impurities, was the object and what the inventor was really aiming at was the

prevention of invisible loss and also incidentally, at the same time, keeping down the ash content. Invisible loss is a big thing and purification of the air is, to my mind, largely camouflage.

Mr. HELMKAMP—Only pure air enters the purifiers, which are made air tight. Only washed air comes in contact with the grain.

Mr. PRICE—I would like to ask Mr. Bailey, by reducing the invisible loss, do you mean that this is an opportunity to add enough water to overcome this?

Mr. BAILEY—Enough water to offset that which would be lost in evaporation.

Mr. PRICE—We had that same question come up at Chicago. Occasionally we suggest something which apparently conflicts with the law. In the grinding of oat hulls, we thought by restoring the moisture to the original amount we might reduce the danger of dust explosions. The difficulty has been to tell where to stop.

Mr. BROWN—It occurs to me that if air can be used in this installation why not use an inert gas and remove all danger of explosion?

Dr. BAILEY—It would require an enormous quantity assuming you could keep it all there after you once put it there. May I ask, Mr. Brown, in the consideration of the use of inert gas, I presume you propose taking it from the smoke stack and purifying it in some way.

Mr. BROWN—Yes, it would be taken from the stack and enough added to the air to reduce the oxygen content to probably not over 15 per cent.

Dr. BAILEY—There is always an element of danger in taking gas from the smoke stack owing to the big percentages of SO_2 and SO_3 . Unless they are completely removed their subsequent introduction into the flour system would be very dangerous.

Dr. BROWN—That is a rather interesting question to me, because we started this work on inert gas $3\frac{1}{2}$ to 4 years ago. In 1917, at one of the large industrial plants, we were doing some work on that and naturally ran into the objection which Dr. Bailey has raised. In order to overcome this, we arranged to pump flue gases into a barrel or box in which flour was

being continually agitated by tumbling. Taking first ordinary flue gas, which had been thoroughly washed, and then gradually running up the impurities until they were very high, on account of incomplete combustion of the coal, and the gases not being washed, not until we could actually observe by the naked eye impurities in the flour was there any very noticeable effect. According to tests made at the Government Laboratory at Chicago and further tests, including baking tests, made at the Department Laboratory in Washington, not until we could actually smell in the flour, or coming from the flour a distinct odor of flue gases and could observe in them the foreign particles of soot, did we find any deleterious effect.

Dr. BAILEY—Was the effect judged by the size of loaf or was it a test of the flavor?

Dr. BROWN—Both the sponging test and several others were run. In fact, no effect was noticeable until the flour had actually been in this atmosphere of gas, agitated continually, for about $2\frac{1}{2}$ to 3 hours, which is considerably longer than it would be in the presence of any inert gas in passing through an ordinary milling process where inert gas might be used.

Mr. BAILEY—That sounds like pretty conclusive evidence. We are always concerned by the presence of SO_2 . It is very antagonistic to yeast and has a harmful effect on the gluten of flour where greater quantities of SO_2 might not affect other cereals at all.

As I recall Mr. Helmkamp's description of this process, this air is used principally in machines where we don't ordinarily regard the explosion hazards as very high. So the use of inert gas wouldn't be as significant as in some other places. Especially as this process uses humid air perhaps the danger of explosions is more remote than in dryer air.

Mr. HELMKAMP—The principal objection is that it makes added trouble for the miller to keep the thing regulated properly at all times.

Mr. PRICE—We must remember that the flour milling industry is not experiencing the number of explosions that the other industries are, the grain elevators for instance, and starch and sometimes sugar. The inert gas theory has not been developed with the flour industry particularly in mind. We felt that it might be applied to the grinding of oat hulls, but it hasn't been given serious consideration in connection with flour milling.

Mr. BATES—We now come to the paper of Dr. H. H. Brown on the results and impressions in dust explosion meetings. Probably no other man has come in contact with the general public in a more intimate way in connection with this work over the whole country than has Dr. Brown. He has been the main spokesman at a great many meetings throughout the entire country. He, being a chemist, naturally has noticed certain reactions to his "air" efforts and we will now listen to his summing up of how the public received the explosion of dust propaganda.

RESULTS AND IMPRESSIONS IN DUST EXPLOSION MEETINGS.

By DR. H. H. BROWN.

To give a complete discussion of this subject at this time seems unnecessary, since most of you are familiar with the meetings held in your district, and know about many of the other points which were reached. There was a certain similarity in these various meetings, and yet they were different. So perhaps a brief discussion of the results of the meetings and of the impressions which I received in them will be of benefit.

As you know, two series of meetings were held. The first started in January of 1918 and continued through May and until early June of that year. The other started the 20th of last October and the last meeting was held on the 30th of March of this present year. In that time over 100 meetings were held. In some cases, the attendance reached eight or nine hundred, while in others only about a dozen or fifteen were present. But in every meeting the same method of presentation was followed. While, of course, we appreciated having as large an attendance as possible, we always felt that the small meetings were worth while because in them we seemed to get into more intimate touch with those present. This may have been due to the fact that the men felt freer to enter into the discussions which we always had following the presentation of the subject.

It often happened that at points where we did not anticipate having a very good meeting, there we had some of the best. For instance, at one point we did not have a meeting in the first series because we felt it was not very accessible and there was not the interest apparent as at some places, and the milling capacity was not large. This point was reached in the second series. Arrangements were supposed to have been made in advance, and while on arrival there was not much that I could see to be done, except

get my own equipment ready, still there did not seem to have been much interest aroused. But when it came time for the meeting, the men began to file in, first one at a time, then by twos and threes, and finally a dozen or more at a time, until fully a hundred were present. It developed to be one of the liveliest and most interesting meetings which was held.

One of the most satisfying things in the two different series of meetings was the increased interest shown in the second meeting. For instance, at one point only a few over two hundred attended the first meeting, and many did not stay for the discussion which lasted less than half an hour; but over four hundred attended the second meeting and most of them stayed for the discussion which lasted fully an hour, and after that several stayed to go over some particular questions of immediate interest. A few figures may well be used to show how the interest increased. In 1918 we visited about seventy different points and had an attendance, as shown by signed-cards, of 3,172. At thirty-eight different points this year we had 2,637 signed cards. Cards were not used in four other meetings this year. At these forty-two meetings there was an estimated attendance of about 6,300 people. In 1918 the estimate was about 5,000 for all of those points. I feel that the increased interest which has been shown in this work during the past year has been largely due to the activities of the Grain Corporation and to the fine co-operation that was given by the Zone Agents, to the publicity given through them and the interest which they aroused.

The National Board of Fire Underwriters deserve a great deal of credit for what they did in helping to make the meetings so successful. Through their activity, large numbers of insurance men and fire inspectors attended. These men often said that after listening to what I had to say and after seeing the pictures and the demonstrations, that they knew more what to look for when inspecting a plant, and that they had some argument which they could utilize in speaking with the men in the grade in trying to get them to put in safety precautions. I feel that they are going to extend the work and carry it on in that way.

We always had discussion in the meetings. Numerous questions were asked, but I think that we learned probably as much if not more from side discussion after the meetings were over, at least as to how the work was received. For instance, a man who had been active in arranging for the meeting at Denver, told me after the meeting that a man sitting right behind him spoke to his friend nearby and said: "Well, I did not have any

realization of this thing; believe me, I am going home and get my broom busy." At a meeting at Fort Worth, Texas, a man said: "I often go down into the basement to clear a choke or for some other reason. I have electric lights down there, but sometimes I forget to turn on the switch, and so I just strike a match; you can bet I will never do it again."

Of these recent explosions, the one which occurred in Kansas City probably created the most interest. This may have been because it was the most recent and on account of the large loss of life. Many false impressions and opinions had been obtained which it was necessary to correct. For instance, at one point, the report was current that the explosion had been caused by one of our men giving a demonstration. This little explosion was supposed to have started the larger one. It was necessary to correct this report before a place could be secured for holding the meeting, because they were afraid of our destroying the building.

I feel that the general impression of the trade is largely this: That until this work was started, until this campaign was put on, they had no realization at all of the hazard, the inherent hazard there is in dust. This has been expressed by men from one end of the country to the other. They had no idea of the damage that could be done, of the ease with which the dust could be ignited, and really wondered, as do we, why more explosions do not occur. The large number of inquiries which are coming in daily is a very good indication of what the meetings have done and of the amount of interest that was aroused. It was not possible to go into detail on the various questions and these are being sent in as well as a large number of most interesting and unique inquiries and suggestions. Several companies have asked where vapor-proof globes could be obtained, and after receiving the information have installed them throughout their plants. One of the most frequent inquiries on methods of prevention has been for details of how to eliminate static electricity. These are only a few of the points upon which we are asked to give advice.

You may be interested in some of the questions that were raised at the meetings in various sections of the country regarding the different phases of the work. One of the things probably brought out as much as anything in the discussions during this recent series of meetings was the question of construction of plants; what is the best construction to be used. Naturally, that came up as a result of the explosions which have occurred these past few months in plants constructed of fireproof material.

From some of the questions asked along this line by insurance representatives, it could be seen that the insurance interests were gradually coming to feel that they must increase the rate of insurance on grain, and increase it on grain stored in fireproof plants. It seems to me that that is one thing we must counteract. They have not realized the fact that it is not the grain that is damaged, but that it is the plant. Very little grain has been lost in any of these explosions.

It was only natural that preventive devices should have been of considerable interest. In discussing that question, men would state that they had a certain type of installation in their plant and asked our opinion of it. As a result of the meetings and discussions, it seems to me that one of the big fields for development in cleaning devices, as applied to mills and elevators, is in a vacuum dust collecting and cleaning system. I feel that the majority of the plants would put in such an installation and do it gladly. There is not one of these operating successfully at the present time, and I think that is something upon which we men who are going out might do well to put a little time.

The points which were discussed in the meetings varied in different sections of the country. For instance, in the Pacific Northwest, where considerable work has been done on the question of static electricity in threshing machines, and in the South, where we studied its effect in cotton gins, it was only natural that much of the discussion should be on the causes and means of prevention of static electricity. In the Northwest and up through the Dakotas and Montana, they were very much interested in the question of explosions in country elevators. At Great Falls, Montana, where we had two meetings, one in the Spring of 1918 and one in the Fall of 1919, they were very much interested in this question, and at each of these meetings we were told of explosions in these types of elevators. When a milling center was reached, the questions were along lines of prevention of explosions in mills, and in a grain handling center, the prevention of explosions in elevators was the chief topic of discussion.

Considerable interest was shown in our discussion of explosions being caused by sparks struck by foreign material passing through grinding machines. At almost every meeting men in the audience cited cases where small explosions had started from such causes, and these brought forth some very interesting discussions. This would lead to the question of preventing the propagation of these explosions beyond the grinding machines,

While in the East we had rather been working toward the revolving damper, in the West they were working toward the use of a choke conveyor equipped with a vent between the choke and the machine. Personally I feel that this device is really as effective, if not more effective, than the revolving damper.

The discussion of explosions in plants other than cereal plants, such as the explosion which occurred in a spice plant at Cincinnati, brought out several questions as to what types of dust will explode. In Los Angeles I was asked the question whether the dust that the housewife sweeps up around the house will explode, and what was the danger of getting too much dust in the home. At another point a man wanted to know if road dust would explode, possibly figuring on using it instead of gasoline.

Carelessness of operation, imperfect equipment, the possible effect of weather, of humidity and of temperature, and many other questions, came in for their share in the discussion. The question of collecting the dust at the source, at the point of origin, brought out a great deal of interesting and fruitful discussion. An interesting case was found in Detroit where a hood had been placed over the grating at the point of unloading of the cars to remove the dust at that point and to keep the unloading station clean. It is interesting to note that they had kept track of the amount of dust and found that they collected about eight pounds for every thousand bushels of grain. Some agreed that it was the best thing to do from the standpoint of preventing explosions, while others could not see beyond what seemed to be a real or imaginary monetary loss. In practically every meeting the discussions were very interesting and profitable, and much valuable information was obtained in them.

We have all run across some interesting instances of small explosions or of means of demonstration. One which came to my attention was that a number of children were in the habit of playing on a dump where dust had been thrown. Some of the dust was smoldering and the boys would take cloth bags and fill them with dust and shake them over the smoldering mass, just to see the flames shoot up. One of the boys was badly burned as a result. But I think the most interesting story which came to me was told by a man in Stockton, California. He had worked for some time in lumber camps, and when he saw our demonstration with the cheese cloth, he said: "That is exactly like what we used to do to get rid of the flies in the camp kitchen. Even though we had screens, sometimes the kitchen would get so full of flies that the cook would reach into the barrel for a handful

of flour and throw it over a piece of burning paper. The flame would shoot through the room and burn the wings off the flies. Then he would sweep them out." They called it "shooting the flies."

The expressions of appreciation that we received at every point throughout the country were really very gratifying. I think it has been specially so in this last series of meetings. Many expressions of appreciation were received from the milling and grain trade and insurance interests of the fact that the Grain Corporation saw fit to continue the work during this past year and to extend the work so that they might get the benefit of it. The motion pictures that we had this year made a profound impression. When we showed the explosion in the steel gallery, and especially the starch explosion, you would hear throughout the audience sounds of surprise and wonderment that dust could be ignited so quickly. When they saw the destruction which resulted from explosions in the plants, and were told of some of the things found in our investigations, as for instance, in the Cedar Rapids explosion, that a child sleeping in a bed half a mile away from the plant was thrown out of bed and killed, they were very much interested. The men in the grain interests have begun to think of these things at least, and I feel that a great deal of good has been accomplished.

Mr. MOORE—Any important explosions in the last six months?

Dr. BROWN—No, not in elevators. There was one in a flour mill in Denver, but that was a minor explosion, no loss of life. Another occurred in an aluminum plant at Manitowoc, Wisconsin, where six girls were killed; that was an explosion of aluminum dust. That was all.

Mr. BATES—I think probably the present paper is debatable, but I will ask Mr. Price to take the chair in my place.

Mr. PRICE—You have just heard from Dr. Brown with regard to the splendid co-operation from the Vice-Presidents of the Grain Corporation and you also have had contact direct with these men in your various districts in connection with inspection work. I know we all feel that a great deal of the success we have had, has been due to the co-operation of the Zone Agents of the Grain Corporation. I want to state that this co-operation with the Grain Corporation has made it possible for the Department of Agriculture to render further valuable

service throughout the country. Dr. Brown has just referred to the very disastrous explosion at Manitowoc, Wisconsin, which occurred in a plant manufacturing aluminum ware, in which six girls were killed and several others badly injured. This is the first case where we have had girls actually killed in a dust explosion. It was my pleasure to be in Madison a few weeks ago and meet the Governor of Wisconsin and also the members of the Wisconsin State Industrial Commission. A number of the Commission had been to our meeting at Milwaukee, which Dr. Brown had conducted there, and had heard a great deal about grain dust explosions. The commission had its engineers go to Manitowoc when this explosion occurred and conduct a thorough investigation, with the result that the U. S. Department of Agriculture and the State Commission are co-operating in the preparation of a code of prevention, which they hope will help to prevent a recurrence of explosions of this kind in that state; the Industrial Commission being very active and very much up-to-date in that particular respect.

Another concrete case whereby we have been enabled to help in this manner has been in connection with the thresher work in the Pacific Northwest. When the thresher explosions occurred there in 1914, the insurance rates were taken off by Insurance Companies owing to the extensive loss to machinery and grain in that section—around a million dollars being lost as a result. Up until last year it has been almost prohibitive, that is, the rates being so high that insurance could not be carried. The rate as it now stands on threshing machines is $11\frac{1}{2}$ per cent. or \$11.50 per hundred. But at a recent conference in Seattle with State Officials and the Insurance Company interests west of the Rocky Mountains, representing some 300 companies, it was agreed that if they equipped their machines with the precautionary measures recommended by the Government, that the Insurance Companies would be able to reduce the rate below the present rate of \$11.50. We are in hopes that they will finally make it around \$4 or \$5.

At the time of the Kansas City explosion we lacked a definite policy as to the recommendations to be made for the removal of dangerous conditions in mills and elevators. At that time the Grain Corporation decided it would be very advisable to work out a definite policy, which we have been following, so that when conditions of danger were found by you men, they could be removed immediately. You will recall

in your various districts, where the elevator operators did not follow out your recommendations, you would call the matter to the attention of the Zone Agent and in many cases he would call the company on the phone and have the condition remedied almost instantly. As I mention this I see a number of the men smiling as they are thinking about particular cases in which that happened. The formulation of that policy rested largely with one of the Vice-Presidents here in New York, and I take pleasure in presenting Mr. Moore to you, and I am sure we would be glad to hear from him at this time.

STATEMENT BY MR. WATSON S. MOORE, DIRECTOR and SECOND VICE-PRESIDENT U. S. GRAIN CORPORATION.

Mr. MOORE—Mr. Price, you, of course, have had a great interest in this work. Mr. Barnes has undoubtedly explained to you just the basis on which we had a right to interest ourselves in it, and that is on account of the large amount of grain and flour that we had at risk which would justify an appropriation that has helped to carry on this work. I certainly congratulate you on the splendid work that you have accomplished. I did not understand that the dust explosion work has had such a wide range, as suggested by Dr. Brown—even getting into the homes, and I had expected him to illustrate how it was possible to prevent explosions in the domestic circle. But you alone know how important the work is which you have done. I have not seen the piles of dust that you men have seen on entering plants; I have not seen the conditions. You have gone in there and you have probably wondered that an explosion had not occurred before then, and you know just what was removed, and you know something of the responsibility of the people you have seen, men who were deadened to your recommendations absolutely and gave you the wooden ear, and I should imagine you had to explain things to them, and then by your demonstrations were able to arouse their interest and finally their investigation and then the adoption of your suggestions.

Now with reference to the proposition here in New York, with these elevators that were cleaned up. In Minneapolis they had such large elevator capacity that they tore down a lot of wooden elevators and made pianos out of them—we never knew before where music came from in the grain business,—but here in New York where the usual elevator capacity is only five and

a quarter million bushels, equal to one large elevator in Chicago, you see what it would mean to cripple the already inadequate storage, by putting any part of the capacity out of business. If the Erie Elevator or the West-Shore Elevator should be blown up and destroyed, it would be a serious thing; it would curtail shipments abroad; it would hamper transportation and it would ultimately seriously affect the producer. So your work is greater than you sometimes might imagine. Then during the war, you had an advantage because it was a period of responsibility on the part of everybody. Men felt they must refrain from bad practices and be more careful and protect property, and all that sort of thing—a patriotic impulse in helping to win the war; the employees felt they had some responsibility toward a successful termination of the war. Now you have been dealing with a reactionary period, among men, and especially among laboring men and the employed men. They feel they are not getting their share of the profits the elevator men are making, and are not interested in their employer's welfare. So you have had to contend with a trying situation, and it is a fine testimonial of the efficiency of your work that you have been able to accomplish so much in this period in the way of reducing explosions and the saving of life and property.

I remember that at a dinner during the war, the speaker said that they would not ask you after the war how you did the thing; they will ask, "Did you do it?" I said to Mr. Barnes, "Don't you take that to heart; they will certainly ask if you fail, why the work was not done." But if the work is a success they will ask how you did it and dig into your records, and the embarrassing thing will be they will forget the fine service that you have rendered. And it is particularly true in your work; you could not go with mandatory authority to compel these things, and so you accomplished it by the persuasive way; you found out how to get to them and explain what you were after. I have seen some of your minor demonstrations and listened to your lectures and seen interest that was entirely dormant thoroughly awakened. I cannot see how it was possible for you to do the work and achieve the accomplishments which you have. And, really you are the men that ought to answer the question that is now put to the Grain Corporation. "Why did you fellows make money out of a Government operation," and one answer is that we never expected to go for two and a half years without a fire loss, when there was at one time at risk four hundred million dollars of property.

You men really belong to the life-savers of the country. You cannot put down the amount of your work; you cannot make a complete compilation of it. You know how many addresses you made; but you cannot compute the lives that have been saved; you cannot compute the property which has been preserved; that goes into the eternal record and we know nothing about it. While you may not belong to the organization of actual life-savers, they only act when life is in peril, but yours is the great work of prevention, which after all is the far more important life-saving agency.

So this work of prevention that you men have been doing; you cannot tell how great it is, and you men can take that reward, which is the greatest reward: "He that saveth life shall find it."

Mr. PRICE—I want to thank you, Mr. Moore, for those kind remarks; they mean a great deal to me, and I know they mean a great deal to you men in your respective fields in the various sections of the country. You have the assurance to carry back with you, that the work you have been doing is fully appreciated. As you know we are going to be compelled to discontinue this work for lack of funds after July 1st. This gives you double assurance in your future work, which will probably be somewhat different from the work you have been doing during the period of the war and since the armistice; and the service rendered has been of a nature, as Mr. Moore said, that cannot be computed; work, the results of which were far-reaching, and has probably assisted in the adoption of additional precautionary measures. I feel, Mr. Moore, that we again want to thank you for your very kind remarks concerning us and the work we have done, and it has been a very great source of gratification to hear it from you. We have been able to help in the protection and improvement of conditions in industrial plants, but we would not have been able to do so without the strong co-operation and far-sighted policies on the part of the Grain Corporation officials.

We will now hear from Dr. Duvel regarding the interest of the Grain Corporation in Dust Explosion Prevention. I feel that Dr. Duvel is the man who was very largely instrumental in steering us on the right track by getting us in contact with the Grain Corporation in this work.

INTEREST OF GRAIN CORPORATION IN DUST EXPLOSION PREVENTION.

By DR. J. W. T. DUVEL.

Dr. DUVEL—I had in mind, in presenting this matter to you this morning, to refer briefly to what this work has meant to the Grain Corporation. Fortunately much of this has already been covered by Mr. Moore at the banquet the other night, by Mr. Barnes in his remarks at our meeting yesterday, and by Mr. Moore again this morning. I am very glad it has turned out that way, particularly for the benefit of you men, because I know you appreciate hearing from Mr. Barnes and from Mr. Moore themselves as to the interest they had in this work. I suspect a great many of you men while in the field have felt that the Grain Corporation was only indirectly interested in this work, and that this thought applied particularly to Mr. Barnes and to Mr. Moore, but I want to assure you, if such assurance is necessary after what you have heard them say, that they have taken a broader view of this question. Both Mr. Barnes and Mr. Moore have been intensely interested in every phase of this work. We got into this work primarily, of course, to protect our large stocks. As Mr. Moore said this morning, at one time we had nearly half a billion dollars worth of property at stake, without one dollar of insurance. But in addition to that, Mr. Barnes has been interested in the educational campaign, authorizing the trip that Dr. Brown has made, which was largely educational, going into sections where we had no grain stored, and also the work you have been doing in the last two or three weeks, going into country elevators, into small plants in different sections, following up the same line of work that you carried on a year ago and two years ago. I am frank to say that in my own mind there was some doubt in the beginning whether Mr. Barnes would care to go that far for fear there might be some criticism of our extending our authority to that extent, but when it was presented to Mr. Barnes by Mr. Price and myself, he immediately said that we could go ahead with this work, and while our own stocks were getting smaller, that he wanted to carry this message home to the people, to do what good was possible at the present time, but more particularly for the future.

We had intended holding this conference as more or less of a conclusion to our work, as you know being originally

scheduled early in May but after I found that the banquet in honor of Mr. Barnes was to be on the 22d, I immediately took steps to have it moved up so that you men could come in and enjoy it as an incidental feature of this conference.

At the present time our stocks of wheat are very low. We have something in the neighborhood of twelve million bushels, practically all of which has been sold, there being four million of that amount due mills, and eight million due for export, leaving a balance net surplus unsold of only 433,798 bushels as of April 16. Of these twelve million bushels we have, most of it is at Buffalo, Minneapolis and Chicago, and we will keep watch on that until it is delivered or finally disposed of.

I think one of the most interesting things you will be able to take away with you, is a point that Mr. Moore indicated this morning, namely, the amount of insurance, or rather the risk assumed by the Grain Corporation. We had this data brought together a short time ago. From October 1, 1917 to July 1, 1919, the average value of the weekly holdings at all points was approximately one hundred million dollars; Buffalo running just under fifteen million, Chicago just under seventeen million, Duluth just under fourteen million, and Minneapolis a little over fifteen million dollars, and the balance being made up with the markets carrying a smaller quantity of stock. Taking these holdings in the various markets at the average rate of insurance applied to most of the houses for that period, we find if we had paid insurance, instead of carrying our own risk, that the premiums during that period would have been \$1,961,500. That is from October 1, 1917, to July 1, 1919, covering a period of twenty-one months. Adding that to the amount we have carried this year, would mean a total in round numbers of three million dollars that we would have paid in premiums on the grain in the elevators. The Grain Corporation carried its own insurance, and that is the reason, of course, we were anxious to see that proper precautions were taken at all points during the entire life of the Grain Corporation. We have not had a single loss by fire. The only loss we have had is in connection with the Kansas City explosion, where our grain loss, in salvaging the grain, if I remember the figures correctly, was \$25,000. We had, of course, some losses both on the Lakes and the Atlantic, but that is outside of our dust explosion field, and in most

cases, in fact, I think all cases, grain moving on the Lakes and going for export was insured and fully protected.

The following tabulation will show in detail the average value of our holdings, average rate of insurance, and the risk assumed, or rather the premiums which the Grain Corporation would have paid if insurance had been covered in the regular way:

Terminal.	Average Value in Store.	Rate.	Remark.	Premium.
Baltimore	\$2,281,865		Estimate	\$18,000
Buffalo	14,856,728	\$0.30	Average	78,000
Chicago	16,723,000	1.40	Average	409,000
Duluth	13,884,380	1.31	Average	316,000
Galveston	2,159,702	1.71	Average	64,500
Kansas City	9,482,892	1.73	Average	287,000
Minneapolis	15,121,329	1.40	Estimate same as Chicago	370,000
New Orleans	4,027,819	None	Included in Ele- vator Rates.	
Omaha	3,829,324	1.68	Average	112,800
Philadelphia	1,743,730	2.00	Average	61,000
Portland	7,585,610	1.00	Estimate	133,000
St. Louis	2,249,478	1.40	Estimate same as Chicago	55,300
San Francisco....	809,300	1.13	Average	16,000
New York	2,486,637	.94	Average	40,900
				\$1,961,500

NOTES.—

1. Period covered—October 1, 1917, to July 1, 1919—21 months.
2. Values were based on the average quantities in store, week by week, over the entire period as reported to the Grain Corporation on daily terminal elevator reports, calculated on the basis of No. 2 wheat.
3. Insurance rates were arrived at by taking the average of all elevators in each terminal for which data were available. (This covered practically all houses.)

There is another point that has been very interesting to me in connection with this work, and that is a statement I saw a few days ago, from report of the National Safety Council, giving the number of persons killed by accident in the United States last year as 80,000. Of this number we had 78 who lost their lives as a result of dust explosions. Seventy-eight, as compared with eighty thousand, of course, is a small number, yet in a city like New York, every day that you pick up a paper you see reports of a number of people killed by accident, and it seems to me, when we take those figures into consideration, that we realize more fully what this dust explosion work really means; and as Mr. Moore has said, the number of lives that have been saved by preventive measures is something we shall never know.

I do not know that it is necessary for me to take up any more time. I wish to say, however, it has been a pleasure for me to have been associated with you men in this work. I have purposely kept in the background as much as possible because I was in hope that you would be able to go ahead with the work in the United States Department of Agriculture next year, and I desired you to have the credit you so fully merit. It is a great disappointment to me that you will not be able to do it, but I hope that some time in the near future Congress will see the wisdom of continuing this work in the Department. As you men leave this work, I am sure it will be with the satisfaction that you have rendered excellent service, even though you cannot point directly to lives you have saved. Again, I wish to repeat it has been a pleasure to know and to work with you. If anything comes up where I can help you in your new work along similar lines, or any new lines that you may undertake, I am sure it will be a pleasure for me to do it.

SUMMARY OF DUST EXPLOSION AND FIRE PREVENTION CAMPAIGN.

By D. J. PRICE.

ORIGIN OF CAMPAIGN.

The Grain Dust Explosion Prevention Campaign was inaugurated October, 1917, by the Department of Agriculture. The disastrous losses as a result of explosions and fires in mills and elevators emphasized the importance of taking all precautions to conserve our food supplies in connection with our war activities. The investigation of a number of these explosions very clearly indicated that the employees and officials were not fully acquainted with the causes under which these explosions could originate and methods that might be followed for their prevention. The campaign was conducted in co-operation with the Food Administration and other conservation commissions until June 30, 1919, when the war emergency appropriation terminated.

GRAIN CORPORATION CAMPAIGN.

At the termination of the war emergency campaign provision was made by the U. S. Grain Corporation through Mr. Julius H. Barnes, President, to maintain sufficient organization to protect the Government's wheat and flour stocks in storage from explosion and fire hazards. This work has been carried on actively during the past year and special attention has been given to the

plants in which these stocks were handled or stored. Frequent inspections have been made from time to time and assistance rendered in the removal of dangerous conditions that might lead to explosions and fires.

EDUCATIONAL WORK.

In addition to the visits to the plants for the removal of these dangerous conditions special educational work was conducted among the employees and officials. The pledge cards used during the war period by which the moral support of the men was enlisted gave very valuable results. The work was presented to the men by means of specially prepared photographs showing the damage to mills and elevators as results of dust explosions and also preventative methods that should be followed. Demonstrations of dust explosions were produced in order to show the men the simple manner in which these explosions could occur. Every effort was made to fully acquaint the workmen with the information that the Department had acquired and to give them the full knowledge of the dust explosion and fire hazard.

LITERATURE.

In this campaign special literature prepared in simple readable language was provided. During the war period a specially designed wall poster entitled "Save Lives, Save Food and Save Property" was distributed throughout the mills and elevators. This poster contained a list of the simple precautions that might be followed to prevent these occurrences. The circular entitled "Prevent Dust Explosions and Fires," and also the small folder known as the "Capitol" folder were prepared for distribution among the employees. This circular and folder contained a number of lessons that impressed the workmen.

During the Grain Corporation Campaign a specially colored wall poster showing the results of carelessness and the benefit of cleanliness was used with good results. A circular entitled "Just a Word About Grain Dust Explosions" containing an account of 8 explosions due to causes controlled by the workmen, together with 12 rules for safety was issued. The small folder entitled "4 Reasons Why You Should be Careful" was well received by the workmen and a wide distribution was given.

The demand from the milling and grain companies, insurance people, conservation associations and other interested parties has shown the value of this literature.

CO-OPERATION.

In the campaign active co-operation has been given by the milling and grain trade, insurance and conservation commissions, fire prevention agencies and state officials. The presentation of the work throughout the country has been wonderfully benefited by this co-operation which has endorsed the efforts of the Federal Government and made it possible to apply the preventive methods in a practical manner. This opportunity is taken to express appreciation for the co-operation and assistance rendered by these agencies. What success may have attended this campaign is due to a large degree to the splendid co-operation given the Government in this work.

DUST EXPLOSION MEETINGS.

In addition to the group meetings held at the plants to acquaint the workmen with the dust explosion fire work, a series of meetings were held in the larger cities throughout the country. These meetings were attended by members of the grain trade and other interested parties and specially prepared motion picture reels were used. These films showed the results of both laboratory and large scale explosion experiments, together with views of large mills and elevators damaged by explosions and fires accompanied by large loss of life and foodstuffs. In addition to the meetings in the United States, at the request of the Dominion Fire Commissioner a meeting was held at Fort William, Ontario. Interest in the work was awakened in Canada as a result of the Port Colborne explosion and the meeting was well attended.

CONVENTIONS.

In addition to the public meetings held in the larger grain centers throughout the country the work was presented at a number of conventions in the United States. Among these are included the National Fire Protection Association, National Firemen's Association, Railway Fire Prevention Association, Illinois State Firemen's Association, Iowa Grain Dealers and conventions of several millers' associations. At these conventions the motion pictures were used and demonstrations of dust explosions produced by means of a miniature elevator, and also by sifting the dust through a cheese-cloth onto a burning match. These demonstrations were similar to those given at the meetings held in the larger grain centers and at the various grain plants.

METHOD OF REPORT OF INSPECTION.

The results of the inspection of the elevators were reported both to the district and to the Washington office. The following method of classification was used:

Equipment	Maintenance
A. Modern, first-class, up-to-date appliances.	A. Good.
B. Fair, not new.	B. Fair.
C. Old and not representative.	C. Poor.

A well constructed plant, with modern mechanical appliances, would be given "A" for equipment. If precautionary measures were being carried out, and the explosion hazard recognized, the plant received "A" for maintenance. The classification for such a plant would then be "AA." If the maintenance was not up to the standard and the dust conditions looked after in only a "fair" manner, the classification would be "AB." If the plant was well equipped, but found in a dirty, dusty, or poor condition, it would receive a grade of "AC." In many cases, however, equipment which was not strictly modern, but was rendering satisfactory service was put in the "B" class to distinguish it from that of newer type or design. If the plant was well maintained it would be classed as "BA," while "BB" and "BC" represented the intermediate and poor classes, respectively. Old type plants, in which the equipment had been installed for some time fell in the "C" class. When it was well maintained and particular attention was paid to the removal of the dust conditions, the plant would be placed in the "CA" class. Similarly, "CB" and "CC" represented the other grades of upkeep and maintenance.

These reports also were sent immediately to district headquarters and then to Washington, so the officials in charge could at all times keep in close contact with the general conditions of the mills and elevators throughout the country. By comparison with previous reports, it was possible to determine whether or not the condition of the elevator was improving and whether the precautionary measures previously recommended had been adopted.

IMPROVEMENT IN CONDITION OF PLANTS.

That conditions in the mills and elevators inspected were materially improved as a result of the recommendations made to the officials in charge is evident from the report turned in

by the field men. The following table gives a few typical cases of the results of this phase of the work:

Elevator	Visit	Date	Grade
1 (Middle West)	1	September 4, 1919.....	AC
	2	September 26, 1919.....	AB
	3	February 18, 1920.....	AA
2 (East)	1	September 23, 1919.....	AC
	2	November 29, 1919.....	AB
	3	March 5, 1920.....	AA
3 (East)	1	November 26, 1919.....	BC
	2	March 1, 1920.....	BB
	3	March 20, 1920.....	BA
4 (West)	1	September 11, 1919.....	CC
	2	October 17, 1919.....	CB
	3	February 4, 1920.....	CA
5 (East)	1	August 19, 1919.....	AA
	2	December 17, 1919.....	AA
	3	January 28, 1920.....	AA
	4	April 13, 1920.....	AA

Elevators 1 and 2, although well constructed and equipped with modern machinery, were poorly maintained at the time of the first inspection. As a result of following the recommendations made by the inspector, conditions were so improved that when the last inspection was made the plants received the grade of "AA."

Although elevator 3 remained in class "B" (medium) for equipment, it improved sufficiently in condition to rise from "C" to "A" in maintenance.

Elevator 4 was poorly equipped and very poorly maintained, showing evidence of but little precaution against fires and explosions. The information received by the officials, however, enabled them to bring their grade up to "B," and finally, after they had adopted additional methods of dust explosion and fire prevention, to "A." The equipment in this plant was not improved, remaining in the "C" grade.

Elevator 5, modern in construction and equipment, was found at the time of each visit to be in an excellent condition and provided with every device for minimizing the dangers from dust explosions.

As this summary is representative of the large number of

reports received from all over the country, it may be concluded that the recommendations made in this campaign brought about an improvement in conditions and a decrease in dangers from explosion and fire in the mills and elevators of the United States.

CO-OPERATION OF ZONE AGENTS.

As a result of a disastrous explosion in a Southwestern elevator, a definite plan of co-operation with the zone agents of the Grain Corporation was provided. When the plants were found to be in a dangerous condition a report was immediately made to the second Vice-President of the district with the result that steps were at once taken to remove this condition. In many instances it was felt that explosions were prevented by this action when prompt steps were taken to remove the hazard that had been found by the engineer upon a visit to the elevator or mill. It was a splendid example of how results could be obtained by calling the matter to the attention of the officials in charge.

ELECTRICAL DEVELOPMENTS.

Investigations of explosions during the period of the campaign indicated the possibility of dust ignition by the breaking of incandescent lamp bulbs. The matter was taken up with the manufacturers of lamps and a co-operative plan provided. At present the National Lamp Works of Cleveland, Ohio, the Westinghouse Company of Bloomfield, N. J., and the Edison Lamp Works of Harrison, N. J., are working on the problem. It is hoped that as a result of this combined effort that safety equipments will be provided and safe practices can be developed. This is an important matter and will be given thorough consideration. In the experimental tests already conducted explosions have been readily produced by the breaking of the bulb in dust clouds. An effort is now being made to determine the effect of dust settling on these bulbs and the relation to explosion and fire. Several conferences have been held with the representative lamp companies and a definite program of research investigational work has been outlined.

FURTHER CO-OPERATION.

Following the investigation of the explosion in the aluminum goods manufacturing plant in Wisconsin a conference was held at Madison with representative commissions. Special attention will be given to the elimination of dangerous dust hazards in that state with the possibility of a prevention code being provided.

Since the explosion at Port Colborne we have co-operated in an active manner with the Canadian Government officials, insurance commissions and other fire prevention agencies in the Dominion. It is hoped that this co-operation will continue and lead to a combined effort on the part of both governments to conduct further investigational work.

THRESHING MACHINE EXPLOSION PREVENTION.

During the past year the devices developed by the Department for the prevention of threshing machine explosions have been recognized by the insurance interests in the Northwest. At a recent conference in Seattle with representatives of the insurance companies favorable consideration was given looking forward to a reduction in the existing rates in cases where the preventive equipment is used on threshing machines.

LACK OF APPROPRIATION.

The Dust Explosion Prevention Campaign will terminate to a large extent June 1. It may be necessary to maintain part of the organization to protect the Grain Corporation stocks still remaining in the elevators until about July 1.

Unfortunately, the present Congress has made no provision in the appropriation for the Department of Agriculture for the Dust Explosion Work. The war emergency appropriation terminated July 30, 1919, and since that time the organization has been financed by the U. S. Grain Corporation. The Secretary of Agriculture submitted to the present Congress an estimate of \$100,000 for the investigation and prevention of dust explosions and fires. This included three lines of work: First, explosions in mills and elevators; second, threshing machines, and third, cotton gins and, included the lines of work which the department would like to carry on.

The bill as reported by the Agricultural committee of the House contained an item of \$25,000 for the dust explosion work. A point of order was made against the item on the floor of the House on the ground that it was new legislation, which was sustained by the chair, with the result that the item was stricken from the bill before it passed the House.

The Secretary recommended to the Agricultural committee of the Senate that the item be reinstated in the bill before being reported to the Senate. Unfortunately for some reason this was not done and the bill as introduced and passed by the Senate contains no provision for the work.

This is to be regretted because the Department will not be able to carry on the investigations planned pertaining to the Dust Explosion Work. The organization must be disbanded and the work cannot be taken up in an active manner until the necessary appropriations are made. The Department feels that owing to the very close relation to the saving of life, food and property that provision should be made for the continuation of the work.

RESULTS OF CAMPAIGN.

The Grain Corporation has handled practically the grain crop for approximately three seasons. The stocks have averaged about \$100,000,000 in value and have reached in some instances \$500,000,000. With the exception of a slight loss as the result of an explosion in a Southwestern elevator the entire Grain Corporation stocks have been handled without any extensive dust explosion and fire losses. This is a very significant fact when we consider that disastrous dust explosions have occurred in other industries. During the period of the last twelve months, at least seven of these explosions have occurred involving loss of life and property. The total life loss will exceed eighty and the property damage over \$7,000,000.

The results obtained in the campaign indicate that through the co-operation with the officers and workmen at the plants and the various fire prevention agencies, these dust explosions and fire losses can be prevented.

Investigation of these recent explosions, however, has developed new causes and necessity for additional lines of research work. This is included in the program provided by the Department of Agriculture which cannot be taken up until Congress makes the necessary provision. It is felt that this investigational work must be continued and effective methods of prevention developed before we can reduce the loss to life, foodstuffs and property in our large industrial plants.

APPRECIATION OF WORK.

We fully appreciate the assistance that has been rendered by the men engaged in the campaign and the faithful manner in which they have performed their work. It has made it possible for the Government to bring to the attention of the men in the plants the extent to which they control these explosions and fires and to see that the necessary steps are taken for their prevention. It is a source of very great gratification to close the campaign and feel that some definite results have been accomplished which

are fully appreciated by the Grain Corporation, and milling and grain trade throughout the country. It is hoped that provision will be made in a very short time for the proper continuation of the investigational work. In closing this summary we desire to express our sincere appreciation of the interest shown by Mr. Barnes in the work, and the endorsement and recognition given by the entire Grain Corporation organization. It indicates the important relation of the dust explosion prevention to the country, and the necessity for its continuation until the dangers surrounding the causes are fully understood, and effective methods of prevention can be developed.



DUST-FREE

Mills and Elevators

are **EXPLOSION-
PROOF**



Carelessness

a lighted match
dusty machinery
an uncovered candle
or lantern
friction in machinery

Cleanliness

means nothing to
explode
protects workmens' lives
saves property
saves food



U.S. Grain Corporation ~
U.S. Department of Agriculture

For further information about grain dust explosions write to the
Bureau of Chemistry, ... U.S. Department of Agriculture